RESPONSE OF *PISUM SATIVUM* L. TO EXOGENOUSLY APPLIED PLANT GROWTH REGULATORS

ABSTRACT

THESIS
SUBMITTED FOR THE DEGREE OF
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IN
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DEPARTMENT OF BOTANY
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Response of *Pisum sativum* L. to exogenously applied plant growth regulators

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Abstract of the thesis, submitted to the Aligarh Muslim University, Aligarh, India, for the degree of **Doctor of Philosophy in Botany** 2000.

The seeds and/or the seedlings were fed with the hormones (IAA, IBA or GA_3) to improve their vigour. The whole study was grouped under four experiments. The salient features in each of the experiment are mentioned below:

Experiment 1

The seeds of pea cv. Arkil were soaked in water (C_1) and 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M aqueous solution of GA_3 (H_1), IAA (H_2) or IBA (H_3) for 6 (S_1), 12 (S_2) or 18 (S_3) hours in sterilized petriplates at 25±2°C.

The level of NPK, nitrate, NRA, total protein and soluble and insoluble carbohydrates improved in the embryonic axes with the progress of germination but decreased in the cotyledons. However, the treatment remained ineffective in inducing any impact on any of these parameters of the seeds upto 18 hours of soaking.

Experiment 2

The seeds treated with hormones (Experiment 1) were sown in the pots filled with acid washed sand. The resulting seedlings were sampled 25, 35 and 45 days, after sowing and assessed for their length, fresh and dry weight of the shoot and root, separately. They were further subjected to chemical analysis for NRA, nitrate, NPK, protein and carbohydrate contents

both in the root and the shoot, separately. The auxins and the gibberellin significantly improved all the growth characteristics of the root and the shoot, respectively. The level of the nitrate in the root only and that of NRA and soluble carbohydrate both in root and shoot was enhanced by GA_3, whereas the nitrate content in the shoot increased by IAA. The treatment was most effective if the seeds were soaked for longer durations (12 or 18 hours) in the higher concentrations (10^{-7} or 10^{-5} M) of the hormones.

Experiment 3

The surface sterilized pea seeds were sown in acid washed sand, in the pots. The seedlings were supplied with 10^{-9}, 10^{-7} or 10^{-5} M of the hormones (IAA, IBA or GA_3) in association with the nutrient solution, once (7th or 14th day) or twice (7th and 14th day), after the emergence of the seedlings. The seedlings were sampled and assessed for various characteristics (Experiment 2). The various root and shoot growth characteristics were significantly enhanced by the treatment. GA_3 was most prominent in improving majority of the components, both that of the root and the shoot. Supply of the hormones twice prevailed, in its effect, over single application.

Experiment 4

This experiment is the combination of Experiment 2 and 3 where the seeds pre-treated with hormones (Experiment 2) were sown in acid washed sand and the seedlings were supplied with additional quantity of the hormones (Experiment 3). The seedlings were sampled and analyzed on the same pattern as in Experiment 2. It was noted that auxins proved best in improving the growth characteristics of the root whereas the shoot gave maximum response to GA_3. Like Experiment 2, repeated application of the higher concentrations (10^{-5} or 10^{-7} M) of the hormones proved superior than single application. In root, the auxins improved NRA, nitrate and soluble carbohydrates whereas NPK and proteins exhibited a significant response to GA_3. Moreover, auxins proved best for the shoot nitrate content but NPK, proteins and soluble and insoluble carbohydrates were largely influenced by GA_3. Most of the factors interacted significantly, mostly at the early stage of growth (25 DAS) only.

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CERTIFICATE

This is to certify that the thesis entitled, "**Response of *Pisum sativum* L. to exogenously applied plant growth regulators**" submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Botany is a faithful record of the bonafide research work carried out at the Aligarh Muslim University, Aligarh, India by Mr. Arshad Hussain under my guidance and supervision and that no part of it has been submitted for any other degree or diploma.

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CONTENTS

Chapter 1

INTRODUCTION

INTRODUCTION

The population pressure necessitated the exploration and application of proper land use efficiency techniques to maximize production per unit area per unit time. The present situation, therefore, demands the adoption of judicious crop and soil management practices to achieve higher production potential. The success of "Green Revolution" in India, in sixties, was the result of the introduction of higher yielding cultivars grown with optimal dose of chemical fertilizers. However, the yielding capacity of many of these crops has now attained a plateau. The application of the additional quantities of these fertilizers is not only proving to be wasteful but also counter productive. Moreover, the use of excess level of nitrogenous fertilizers is resulting in the accumulation of nitrate to a toxic level in the soil and dirnking water (Thenabadu, 1989).

The agrophysiologists are, therefore, looking for ways to break the present yield limits by using other possible ways. They are moving in a direction where the physiological efficiency of the plants may be improved, that includes the photosynthetic rate and nitrogen fixation (Arteca and Dong, 1981; Meena and Goswami, 1992; Hayat *et al.*, 2000a), water uptake (Martin and Northcote, 1982), mineral uptake (Nandwal and Bharti, 1982), leaf senescence (Hopkins, 1995), better harvest index and stress resistance (Kaur *et al.*, 1998) by using plant hormones and growth regulators (PGRs). The role of these chemicals is very prominent in maintaining co-ordination between various physiomorphological processes starting from seed germination to the production of fruits. However, there is no clear picture of tissue specificity in hormone induced response (Trewavas and Cleland, 1983).

A major responsibility for better plant growth and development was largely fixed to the roots whose initiation and proliferation was assigned to the supply of the balanced level of the hormones (Thimann and Went, 1935). However, it was only after World War II, that the role of hormones was recognized in seed germination (Buzarbarua *et al.*, 1999), plant propagation (Koukourikou-Petridou and Porlings, 1997), growth regulation (Vardhini and Rao, 1998), flowering (Lee *et al.*, 1998), fruit setting (Rodrigo and Garcia-Martinez, 1998) fruit growth and ripening (Arteca, 1997) partitioning of photosynthates (Achhireddy *et al.*, 1984) by affecting plant metabolism (Hunje et al., 1991; Miyamoto *et al.*, 1993; Ahmad and Hayat, 1999). It has, therefore, been suggested that there is a regulator for every problem encountered.

The efficiency of the hormone in a particular process is largely determined by its application pattern. The most handy method is the pre-sowing seed soaking in dilute aqueous solution of the hormones (Bisen *et al.*, 1991; Yim *et al.*, 1997). Moreover, the application through the roots was proposed to be superior over leaf application because it ensures uniform distribution of the hormone in the aerial parts and is available in the soil over a longer period of time with facilitated absorption (Arteca, 1997).

It was derived from the review (chapter 2) that there is a serious state of confusion with regard to the use of hormones for improving plant vigour because of conflicting results. This possibly is due to the dependence of the response on a number of factors (i.e., cultivar, plant age, nutrient status both of the medium and the plant, atmospheric variants and the endogenous level of various hormones).

Pea (*Pisum sativum* cv. Arkil) was selected for the present study because of its acceptability by the local farmers in their cropping system. It keeps the soil alive and productive and is considered to be a cash crop. Moreover, it holds great promise for bridging the gap between the present per capita availability of pulses (35 g) in India and the standard set by WHO (85 g). The two best possible ways (seed and/or root application) were adopted to observe the response of pea to the exogenously supplied auxins (IAA and IBA) and gibberellin (GA_3).

The present study was executed in two phases.

(a) The surface sterilized seeds were soaked in sufficient quantity of varied concentrations (10^{-9}, 10^{-7} or 10^{-5} M) of the aqueous solution of the hormones in petriplates for short durations (6, 12 or 18 hours). The cotyledons and the embryonic axes of these seeds were analyzed separately for their carbohydrates, proteins, nitrogen, phosphorus, potassium, nitrate reductase activity and nitrate contents to assess any possible shift in their level and mobilization during this period of germination under the influence of the treatment. These pre-treated seeds were also sown in the pots, filled with acid washed sand. The resulting seedlings were sampled at different intervals. The root and shoot were separately analyzed for various morphological and chemical characteristics.

(b) The same concentrations of the hormones used above (a), were maintained in the nutrient solution applied once or twice to the seedlings raised from the normal seeds or those given pre-sowing seed treatment with the hormones as in (a), above. The seedlings were sampled at the same interval and the root and shoot were analyzed in the same way as in (a).

The following objectives were kept in mind while planning the experiments:

(a) To observe a comparative account of the treatment through seed soaking and root application.

(b) To select the hormone, its proper concentration, the soaking duration and the time of application to the roots.

(c) To trace the metabolic marker for healthy germination and growth of the seedlings.

Chapter 2

REVIEW OF LITERATURE

CONTENTS

REVIEW OF LITERATURE

The genetic make up of the plant is not just sufficient to improve its biological yield. A supply of balanced, optimal level of the nutrients is to be ensured by the application of organic and inorganic manures depending on the soil type. Moreover, plant growth regulators, is an another group of chemicals that has significant role in plant metabolism. However, they have been used to a limited extent to exploit the genetic potential of the plants. In the following pages, the work done on this aspect, has been reviewed.

2.1 Plant hormones

These are the organic substances, other than nutrients, synthesized at specific site/s and transported to other tissues where in very low concentrations evoke specific biochemical, physiological and/or morphological response. They are active both at the site of their synthesis and at remote places.

The plant hormones play extremely important role in the integration of developmental activities. They are also very much concerned with the response of plants to the external physical environment. These factors often exert inductive effects by evoking changes in hormonal metabolism and/or their distribution within the plant (Moore, 1989).

2.2 Types of hormones

Earlier, major lines of investigations led to the characterization of the following five groups of classical plant hormones (auxins, gibberellins, cytokinins, abscisic acid and ethylene). It is now superseded by a view that various other molecules, remotely related with the above hormones, have varied important roles in the regulation of plant activities, that includes brassinosteroids, salicylates and jasmonates. Recent evidences also suggest that natriuretic peptides, known to function as regulators of salt and water balance in vertebrates, may play a role in plants and hence called them plant hormone (Gehring, 1999).

2.2.1 Auxins

Thimann (1969) defined "auxins" as "organic substances which at low concentrations (<0.001 M) promote growth (cell enlargement) along the longitudinal axis, when applied to shoots of plants freed as far as possible from their own inherent growth promoting substances, and inhibit the elongation of roots". Indole-3-acetic acid (IAA) is the natural form of auxin present in majority, of the plants and is the first, among the hormones, to be characterized. Besides, IAA, the other auxins e.g. indole-3-butyric acid (Schneider *et al.*, 1985; Epstein *et al.*,1989), phenyl acetic acid (Leuba and Le-Torneau, 1990) and chloroindole acetic acid (Engvild, 1986) have also been identified in leaves/seeds of some plants. The best known synthetic auxins are naphthalene acetic acid (NAA), 2, 4-dichlorophenoxy acetic acid (2,4-D), 2,4,5-trichlorophenoxy acetic acid (2,4,5-T) and 2-methyl-4-chlorophenoxy acetic acid (MCPA).

2.2.2 Gibberellins

Gibberellins are defined as "compounds having an *ent*-gibberellane skeleton and biological activity in stimulating cell division or cell elongation or both, or such other biological activity as may be specifically associated with this type of naturally occurring substance" (Paleg, 1965).

Of the 121 GAs (Hedden, 1999), that have been identified to date, in plants or fungi, relatively few are thought to possess intrinsic biological activity. GA_3 is the first widely available active form of commercial gibberellins. However, the other recognized bioactive gibberellins are GA_1, GA_4 and GA_7.

This class of plant hormones is involved in the regulation of the important developmental activities throughout the life cycle of higher plants, such as seed germination, stem and petiole elongation, leaf expansion, flower induction and the growth of seeds and fruits (Hedden, 1999).

2.2.3 Cytokinins

Cytokinins are adenine derivatives, which in association with auxin, control cell division and other activities in the plants. The most common and earliest natural cytokinin is 'Zeatin', isolated from immature kernels of *Zea mays* (Letham *et al.*, 1964). Recently, kernel cytokinin level has been quantified in *Triticum aestivum*, which peaked within 3-days, after anthesis (Banowetz *et al.*, 1999).

2.2.4 Abscisic acid

Abscisic acid (ABA) is a sesquiterpene, derived from mevalonic acid. It was originally extracted from cotton bolls (Liu and Carns, 1961). It is thought to be an inhibitor because of its association with abscission and dormancy. It is also known to regulate opening and closing of stomata under stress, embryogenesis, growth and geotropism (Arteca, 1997).

2.2.5 Ethylene

Ethylene (C_2H_4) is the hydrocarbon gas whose hormonal nature was first identified by Neljubow (1901) in etiolated seedlings of *Pisum sativum* where it induced triple response. Ethylene is produced by almost all higher plants, in traces, where it interacts with other hormones, specially auxin to co-ordinate and regulate a wide variety of growth and developmental processes such as shoot elongation on flooding, leaf abscission, floral induction, fruit ripening and sex-determination (Dolan, 1997).

2.2.6 Brassinosteroids

Brassinosteroids (BRs) is a novel group of phytohormones which were primarily extracted from the pollen of *Brassica napus* (Mitchell *et al.*, 1970). BRs are present in low concentrations in pollens, seeds and young vegetable tissues, throughout the plant kingdom (Arteca, 1997).

Microchemical and molecular genetic analysis proved their essentiality in diverse developmental programmes, including cell expansion, vascular differentiation, etiolation and reproductive development (Clouse and Sasse, 1998). Moreover, the research conducted on *Arabidopsis thaliana, Lycopersicon esculentum* and *Pisum sativum* has given convincing evidences that brassinosteroids are essential for normal plant growth (Li and Chory, 1999).

2.2.7 Salicylates

Salicylates is a class of plant hormones having activity similar to that of salicylic acid (SA), which is a plant phenolic compound. SA is widely distributed in the plant kingdom, so far it has been identified in more than 34 species (Arteca, 1997). Salicylic acid has an effect on a number of plant processes. Flowering, heat production in thermogenic plants and promotion of disease resistance are the processes where, it has a major role (Arteca, 1997).

2.2.8 Jasmonates

Jasmonates belong to cyclopentanone group with an activity similar to that of jasmonic acid and/or its methyl ester. It has been detected in 206 plant species and is ubiquitously distributed throughout the plant kingdom (Meyer *et al.*, 1984; Sembdner and Parthier, 1993).

Exogenous application of jasmonic acid promotes senescence, petiole abscission, root formation, tendril coiling, ethylene synthesis and β-carotene synthesis (Staswick, 1992). Moreover, jasmonic acid is also effective in inhibiting seed germination, callus growth, chlorophyll production and pollen germination (Vick and Zimmerman, 1986; Anderson, 1989; Parthier, 1990).

2.3 Effect of hormones

The work related with the exogenous application of phytohormones and growth regulators to the plants and their parts has been categorized under the following headings:

2.3.1 Germination

The initiation of seed germination begins with its hydration and terminates with the elongation of the embroynic axes. The hydrolysis of stored food materials, the mobilization of nutrients, cell elongation and numerous other events are the integrated components of the germination process of the seed (Bewley and Black, 1985). These processes are regulated by a number of factors, of which hormone is one of them. They are present in the healthy seeds in the required quantities (Jacobson, 1978; Gurubisic *et al.*, 1988).

Gibberellins are known to stimulate the germination of dormant as well as non dormant seeds of several plant species. GA_3 treatment strongly stimulated the germination of coated and naked caryopsis of dormant *Avena sativa* (Lecat *et al.*, 1992) and *Avena fatua* (Foley *et al.*, 1993). Similarly, 210 ppm (Laura *et al.*, 1994) and 250 ppm (Dhankar and Singh, 1996) solutions of GA_3 induced better germination in *Muntingia calabura* and *Phyllanthus emblica*, respectively. The germination of the seeds of *Paulownia tomentosa* (Gurubisic *et al.*, 1988) and *Vaccinium myrtillus* (Giba *et al.*, 1993) improved by pre-sowing seed treatment with GA_3. A combination of GA_3 or Kinetin (10mM) with ethrel enhanced seed germination of many ornamental plants (Persson, 1993). It also broke the seed dormancy in *Onopordum nervosum* (Perez-Garcia and Duran, 1990).

The confirmation of the involvement of the gibberellins in various plant process was undertaken by using their antagonists. Therefore, the seeds of *Amaranthus caudatus* were treated with paclobutrazole (PBZ), the germination was lost but was restored by GA_3 or ethephon, the ethylene releasing compounds (Kepczynski *et al.*, 1988). Moreover, the per cent germination and the growth of the seedling of *Cicer arietinum* decreased with an increase in the concentrations of exogeneously supplied polyethylene glycol 6,000 (PEG), but was partially restored by the addition of GA_3 or kinetin (Kaur *et al.*, 1998).

In addition to this, the plant growth regulators (e.g., 2, 4-D, IBA, NAA and thiourea) similarly favoured the process related to the germination of the seeds of *Pisum sativum* (Jacobson, 1978), *Abelmoschus esculentus* (Kumar *et al.*, 1996), *Phyllanthus emblica* (Dhankar and Singh, 1996) and *Cymbidium aloifolium* (Buzarbarua, 1999). Contrary to this, Benzyle adenine (BA) did not affect the germination in the seeds of *Muntingia calabura* (Laura *et al.*, 1994) while, IAA, in association with polyethylene glycol (PEG) totally inhibited germination in *Cicer arietinum* (Kaur *et al.*, 1998).

2.3.2 Growth

The canopy of the plants that we see is the result of an integrated growth of the individual plant part. Mainly, there are two major classes of factors that interact and influence the pattern of plant development. The first and the most important is the endogenous hormones, which establish a coordination among various organs for their definite growth. The second group of factors, exists outside the plant (i.e., the environment) that determines their orientation in space (Salisbury and Ross, 1992). The studies related with growth have been further categorized under various subheadings.

2.3.2.1 Rooting

There is a wide range (easy to root, hard to root and no rooting) of adventitious root forming ability in plant parts under proper conditions. Plant parts, such as stem, root or leaves naturally serve as the source for the propagation in combination with proper chemicals, mechanical and/or environmental conditions.

The root inducing capability in stem cuttings by IAA is well documented (Zeedan and Macleed, 1984). However, the fate of exogenously applied IAA differs from that of endogenous auxin, therefore, both positive and negative responses have been observed (Eliasson, 1980). Both IAA and IBA enhanced the rooting capacity in the stem cuttings of *Pisum sativum*, but the later was a better root promoter than the former (Ahmad and Anderson, 1988a). The presence of light made an additive effect on rooting in auxin treated cuttings (Ahmad and Anderson, 1988b). IAA treatment promoted lateral root initiation in *Pisum sativum*, as a substitute of cotyledon or root tip. However, cytokinin application was inhibitory as a root tip substitute but promoted initiation of lateral roots as cotyledon substitute (Hinchee, 1982). Further, Hinchee and Rost (1986) supported the hypothesis that cotyledons and root tip act together to establish auxin and cytokinin balance along the primary root axis to control lateral root initiation and emergence.

In contrast, to the above observations, both IAA and ACC (1-aminocyclopropane-1-carboxylic acid) reduced the number of roots per cutting in pea and the later increased the ethylene level (Eliasson *et al.*, 1989). However, there was no evidence about the mediation of ethylene in the inhibitory effect of IAA (Nordstrom and Eliasson, 1993). Moreover, the root elongation in *Zea mays* was also suppressed by IAA (Pilet and Saugy, 1987; Neuman and Leon, 1992). Similarly, the presence of cytokinin (Benzylaminopurine) did not favour the production and elongation of lateral roots in pea and also induced the production of ethylene and IAA at the root tip which normally exhibited swelling (Bertell and Eliasson, 1992).

IBA, a commercial auxin, is widely used to promote rooting (Aminah *et al.*, 1995), but it is not equally effective in all the cases (Wiesman and Lavee, 1995). It enhanced the survival rate of the cutting of *Gmellina arborea* (Siagian, 1992). The auxins alone (Singh, 1993) or in combination with NAA (Shirol and Patil, 1995) or kinetin (Buzarbarua, 1999) induced more roots per cutting in *Bougainvillea, Ixora singaporensis* and *Combidium aloifolium,* respectively.

Gibberellins are well recognised for their effect on shoot growth but in certain specific cases it also acted on the roots. The treatment with GA_3 increased root elongation in *Pisum sativum* (Tanimoto *et al.*, 1995). Similarly, in *Lupinus albus*, the treatment increased the length of main root but suppressed the growth of secondary roots (Sidiras and Karsioti, 1996). Moreover, in association with auxin, it favoured the root initiation in pea cuttings (Adhikari and Bajracharya, 1978). The effectivity of GA_3 was also prominent even when the seed treatment was given in *Vigna radiata* (Koukourikou-Petridou and Porlings, 1997).

An etiolation and application of 1% sucrose to the pea cuttings favoured both the length and the number of the roots, per cutting. It was suggested to be due to a shift in the ratio of auxin and cytokinin at the base of the cuttings as they had more auxin and lesser quantities of isopentyl adenine or isopentyadenosine (Koukourikou-Petridou, 1998).

2.3.2.2 Shoot growth

Gibberellins, increase shoot length by increasing their rate of elongation in majority of the plants, including *Pisum sativum* (Saimbhi *et al.*, 1975; Hussain, 1987; Anderson *et al.*, 1988a,b), *Silene armerea*

(Talon and Zeevert, 1990) and *Brassica compestris* (Pressman and Shaked, 1991). The repeated application of the hormone induced a response proportionate to the number of applications in *Pisum sativum* (Sharma, 1982). A combination of various gibbrellins has also very successfully been used. A mixture of $GA_4 + GA_7$ was as active as GA_1 in promoting shoot elongation in the seedlings pre-treated with prohexadione whereas, GA_9 was slightly effective and that was only when used at higher concentrations in *Salix pentandra* (Juntilla *et al.*, 1991). Similarly, GA_4 and 2, 2-dimethyl GA_4 stimulated vegetative growth both in elongating shoots and internode of shoots developing from buds that were quiscent at the time of GA application to *Metrosideros collina* (Clemens *et al.*, 1995).

The efficiency of the gibberellins depended on their application pattern that may be through soil, in drip irrigation (Anderson *et al.*, 1988b), applied to the leaves of standing plants (Mishirkey *et al.*, 1990) soaking and/or spraying (Saxena *et al.*, 1987). However, soaking the seeds in aqueous solution was suggested to be a better technique compared with others (Bisen *et al.*, 1991). Therefore, the seeds of *Oryza sativa* soaked in GA_3 significantly improved shoot growth (Yim *et al.*, 1997; Jeyabal and Kuppuswamy, 1998).

In an antagonistic effect, the seeds of *Pisum sativum* soaked in the aqueous solutions of Triodobenzoic acid (TIBA) and Maleic hydrazide (MH) exhibited an inhibition in growth but it was restored by gibberellin and not by benzyladenine or ethrel. However, the growth inhibition of the cotyledons and axillary buds could not be neutralized (Tan and Seebannek, 1980).

Light has an additive effect on shoot growth in association with gibberellins and auxins (Weller *et al.*, 1994). Similarly, Yang *et al.* (1996), while studying the interaction effect of GA with that of the presence or absence of light, observed that the light had a promotive effect on the stem elongation in GA and auxin treated *Pisum sativum* plants. They suggested that it acted through the auxin-induced cell elongation.

An inhibition in the rate of stem elongation in *Pisum sativum* induced by a temperature fluctuation (i.e., cooler in the day and hotter at night) was overcome by the application of GA but was ineffective if the change in temperature was the other way (Grindal *et al.*, 1998).

Contrary to the belief of Thimann (1977) that exogenously applied auxins have no appreciable effect on the elongation growth of intact plants. The application of auxin to *Pisum sativum* (Hall *et al.*, 1985; Mckay *et al.*, 1994) and/or *Vicia faba* (Cline, 1996) and *Solanum tuberosum* (Kalib, 1992) promoted shoot growth. Its interaction effect with red and white light on the elongation of the top internode of *Pisum sativum* plants was also studied by Haga and Lino (1997). They did not notice any significant effect of either of the spectra.

Moreover, other plant growth regulators (viz., NAA, IBA, Kinetin and tricontanol) also enhanced the shoot growth in *Morus alba* (Setua *et al.*, 1998) and *Cymbidium aloifolium* (Buzarbarua, 1999).

2.3.3 Flowering and fruiting

Among the hormones, gibbrellic acid only is recognised as the flower inducer in specific group of plants (e.g., rosette). The recent observations include that of Gianfagna and Merrit (1998) who reported that the plants of *Aquilegia x hybrida* sims (Rose white) did not respond to the application of benzyl adenine (BA) but in association with GA_4 and/or GA_7, under two temperature regimes, favoured flowering. Similarly, GA_1 + GA_3 hastened flowering in *Sorghum bicolor* (Lee *et al.*, 1998).

The parthenocarpic fruit setting and its development induced by auxin or gibberellins (Garcia-Martinez and Carbonell, 1980) gave a general impression that under natural conditions also it is regulated by hormones (Goodwin, 1978). Moreover, it is supported by some recent observations in *Pisum sativum* where the decapitation (Rodrigo and Garcia-Martinez, 1998) or an application of GA_1 or GA_3 (Santes *et al.*, 1995; Rodrigo *et al.*, 1997) stimulated parthenocarpic development of the fruit. However, the application of auxin to the stump inhibited the process but was counteracted by GA_3. 4-chloro IAA or GA_3 was found to be active in pericarp development which replaced the seed effect (Reinecke *et al.*, 1995) and was also important for fruit growth (Van-Huizen *et al.*, 1996).

2.3.4 Seed yield

An increase in biological yield was recorded in *Lolium speciosum* (Shafi and Khan, 1992; Park, 1996) and *Gossypium barbadense* L. (Sawan *et al.*, 1988) by the foliar application of the plants with IAA, IBA and/or NAA. Gibberellic acid was also equally productive in increasing the yield in *Lycopersicon esculentum* (Tomer and Ramgiry, 1997). Similarly, foliar spray of GA_3 (20 ppm) and cycocel (500 ppm) improved yield in *Abelmoschus esculentus* (Rehman *et al.*, 1994). Moreover, the application of IAA and/or GA_3 increased the yield of *Trigonella foenum-graccum*, where GA_3 alone proved best (Doore and Bharud, 1990).

The application of kinetin to the plants of *Pisum sativum* and/or *Vicia faba* in association with IAA increased its nitrogen fixing ability and final yield (Nandwal and Bharti, 1982) and with GA reduced plant stature and tendency to lodge but increased seed yield (Cors and Falisse, 1987). The other regulators of growth (viz., paclobutrazole, ethephon and triazole) applied on the plants of *Brassica oleracea* and *Vicia faba* reduced their lodging tendency there by increased seed yield (Jung *et al.*, 1987; Hugi and Keller, 1990). In a similar study, the spray of aqueous solution of argrostemin, kaolin or phenyl mercuric acetate increased yield attributes and seed yield in *Phaseolus radiatus* (Arya and Sharma, 1994).

Deviating from the pattern of the treatment the presowing seed treatment in *Arachis hypogea* with GA, IAA, IBA, α-NAA and TIBA improved pod yield, the highest being in α-NAA (5 ppm) followed by TIBA and IAA (Verma *et al.*, 1987). While comparing the efficiency of the treatment by adopting the seed soaking and foliar spray of various regulators (GA_3, GA_{4+7}, NAA, PP-333 and Summi -7), the GA_3 proved superior in improving the yield and quality of *Zinnia elegans* (Grzesik and Chojnowski, 1992).

2.3.5 Metabolism

Water is the major factor that limits the rate of growth and metabolic activity in various organisms. In its support, McIntyre (1987) laid down three basic concepts, involving water (a) to mediate environmental effect on growth and development (b) to establish correlation of growth between various plant parts and (c) to integrate growth and metabolic activity at the level of the cell. Moreover, he also proposed that responses induced in the plants by the application of hormones is a manifestation of their effect on the uptake of water. It is strengthened by the observations, where the treatment of *Pisum sativum* with tricontanole (Henry and Gordon, 1980) and *Vicia faba* with GA_3 (Martin and Northcote, 1982) increased the rate of water uptake by the plants. It is associated with enzyme activity whose level and pattern may undergo slight alteration, under the hormonal influence that has been reviewed in the following pages.

The aleurone layer of cereals is one of the most intensively investigated tissues because of its importance in malting and brewing. Chemists and biologists have, therefore, carried out detailed studies of barley grain function, for nearly two hundred years (Deshmukh *et al.*, 1988). It has been mentioned by Bethke *et al.* (1997) in his review, that a factor responsible for modifying starch was first identified in wheat extracts and that was α-amylase (E.C. 3.2.1.1), the earliest identified enzyme.

Gibberellic acid played a productive role in inducing α–amylase at the level of the aleurone layer cells of barley (Skadsen, 1993; Zwar and Chandler, 1995), rice (Mitsunaga and Yamaguchi, 1993) and wheat (Lenton *et al.*, 1994) but failed to do so under saline conditions in *Zea mays* (Patel and Vora, 1986). Moreover, GA_3, along with Ca^{2+} also increased the level of α–amylase in *Hordeum vulgare* (Jones and Carbonell, 1984). Moreover, auxin induced activity of α–amylase in the attached cotyledons of *Pisum sativum* has also been reported by Hirasawa (1989). The activity of α–amylase, in *Arachis hypogea* was low at 2 and 4 weeks after flowering but subsequently increased and was positively related with endogenous levels of auxin, gibberellin and ABA (Thind *et al.*, 1994). However, GA-induced synthesis of α–amylase was antagonised by ABA (Deshmukh *et al.*, 1988; Bethke *et al.*, 1997).

There are two sets of enzymes, the nitrate reductase (E.C. 1.6.6.1) located in cytosol that reduces the nitrate, absorbed by the roots, to nitrite which is transported to chloroplast and is acted upon by nitrite reductase (E.C. 1.7.7.1) converting it to ammonia, the form of nitrogen used in metabolism. Nitrate reductase (NR) is a substrate inducible enzyme (Afridi and Hewitt, 1959). However, the level of NR is not only influenced by its inducer (nitrate) but also by other factors including light (Cardenas-Nevarro *et al.*, 1999a,b; Singh *et al.*, 1999) and plant hormones (Elliot and Peirson, 1980; Prakash and Kapoor, 1984; Hayat *et al.*, 2000b).

The treatment of *Pisum sativum* plants with IAA and/or GA stimulated the nitrate uptake where the auxin was more effective (Zholobak, 1985). It was supported by Ahmad (1988) who reported a sufficient increase in nitrate content, induced both by IAA and IBA, but the later proved superior. The activity of NR was also favoured by kinetin in *Leucaena leucocephala* (Pandey and Srivastava, 1995) and *Brassica juncea* (Chanda *et al.*, 1998). Similarly, ABA singly or in association with GA increased the NR activity in the roots of *Cichorium intybus* (Goupil *et al.*, 1998), in all the plant parts of *Solanum tuberosum* (Palmer, 1985), *Zea mays* and *Gossypium* species, both under saline and non-saline conditions (Munjal and Goswami, 1995; Khan and Srivastava, 1998). The results of Desouky *et al.* (1989) deviated from those noted above due to unexplained reasons. They observed an inhibition in NR activity in the plants of *Pisum sativum* treated with IAA, GA_3, BA, chloroethylphosphonic acid and PBZ (paclobutrazole) both in roots and shoots. The phenols also improved the uptake of nitrate and the activity of NR in *Pisum sativum* (Posposil *et al.*, 1987). They also suggested the possibility of the phenoxy reaction with IAA and ABA.

Protein content was increased in the plants treated with phytohormones (Schuster and Davies, 1983; Prishchepa, 1997). The protein synthesis was favoured in *Pisum sativum* and *Hordeum vulgare* by GA_3 alone (Callebaut *et al.*, 1983; Nissen, 1988) or in association with NAA, cytokinin and chloromequat in pea (Shende *et al.*, 1987), 2-chloro-4-pyridyl or phenyl urea in *Zea mays* (Stefano *et al.*, 1998). GA_3 treated plants of *Pisum sativum* also possessed larger quantities of proteins even in chloroplast (Maksyutova *et al.*, 1987). Similarly, the pre-sowing seed treatment and/or foliar application of aqueous solution of IAA (40 ppm) and kinetin (20 ppm) to the plants of *Triticum aestivum* increased protein content at the reproductive stage of growth, under field conditions (Hegazi *et al.*, 1995a,b). The other plant growth regulators, triton x-100 surfactant and pix (mepiquat), also enhanced the protein content in *Phaseolus vulgare* (Seier *et al.*, 1991) and *Glycine max* (El-shahaby *et al.*, 1994). Verma *et al.* (1997) observed in *Triticum aestivum* that kinetin treatment not only improved the protein level of the plants but also overcame the ill effect of the salinity by protecting the apparatus involved in their synthesis. However, citrus buds and leaves did not exhibit any relationship between the soluble protein content and the GA concentrations (Blanco *et al.*, 1994). Even more diverging observations were made by Berkovec *et al.* (1987) in *Pisum sativum* where IAA treatment decreased protein level.

The level of the major electrolytes (N, P and K) was significantly affected by the application of various hormones to the plants. IAA alone (Nandwal *et al.*, 1981) or in association with IBA (Basak *et al.*, 1995) or NAA (Meena and Goswami, 1992) increased the nitrogen contents in *Pisum sativum*, Mangrooves and *Cajanus cajan*, respectively. El-Sallami (1997) and Imam *et al.* (1998) treated the seeds and/or leaves of *Narcissus tazetta* and *Faba bean* with ethrel, IBA, B_9 (N-dimethylaminosuccinic acid), GA_3 or unicanzol. The resulting plants possessed larger quantities of nitrogen and most effective was GA_3 (200 ppm). Similarly, GA_3 alone or in combination with N_1-(2-chloro-4-pyridyl)-N_2 phenylurea (4-PU-30) increased the total nitrogen content in the leaves of *Zea mays* (Stefano *et al.*, 1998). However, a reverse trend was observed by the application of GA_3 or ABA to *Lonicera japonica* (Nam and Kwack, 1992) or *Vicia faba* (Abd-El-Hamid *et al.*, 1995).

Growth regulators favourably affect the contents of P and K in the plant (Saimbhi *et al.*, 1975; Jeyabal and Kuppuswamy, 1998). The application of NAA, cytozyme (Cytokinin + auxin + amino acid chelated minerals), CCC, tricontanol and GA_3 to the leaves of *Pisum sativum* (Shende *et al.*, 1987) and GA_3 or ethrel to *Narcissus tazetta* (El-Sallami, 1997) increased the phosphorus content of the plant, GA_3 (25 ppm) proved best. Similarly, GA_3 application to the plants of *Pisum sativum* favoured the uptake of K (Luis and Guardiola, 1981). Ethrel (200 ppm) also increased the contents of both P and K in *Narcissus* and *Viola odorata* (El-Sallami, 1996). Moreover, the application of IAA to the seed or the leaves at the later stage of growth (tillering or heading), elevated the level of P and K of the grain of *Triticum* *aestivum* (Hegazi *et al.*, 1995a,b). However, cycocel (CCC) treatment to orange plants made no impact on the contents of P but K level improved (El-Sabrout, 1996). In an extreme case, cycocel treatment decrease both P and K content in *Punica granatum* L. (Ahmed, 1994).

The carbohydrate level in various plant parts and the fruits exhibited varied response to the hormones. NAA alone (Singh, 1996) or in combination with GA_3, chloromequat or diaminozide (Camargo-e-Castro *et al.*, 1995) and/or ethephon (Vitagliano *et al.*, 1998) increased carbohydrate level in the vegetative parts of vairous groups of plants. Soil type made no impact on the GA_3-induced elevation in the carbohydrate contents in *Ocimum basilium* (Bedour *et al.*, 1995) but has a significant role in *Belanites aegyptica* (Zarad *et al.*, 1998). In *Pisum sativum*, GA_3 application in addition to NAA (Doijode and Rao, 1983), IAA (Miyamoto *et al.*, 1993), kinetin and/or IAA (Mohsen-Awalif *et al.*, 1994) accelerated carbohydrate metabolism. Moreover, GA_3 alone proved most effective in enhancing the carbohydrate level both in the leaves and roots in the last case. However, a mixture of GA_{4+7} acted most effectively in elevating the carbohydrate content in *Brassica oleracea* apex (Fernandez *et al.*, 1997).

Out of the eight endogenous cytokinins detected in the cotyledons of *Cicer arietinum* seeds, only isopentyladenine exhibited a regulatory role on carbohydrate metabolism (Munoj *et al.*, 1992). The exogenously added kinetin not only improved the total carbohydrate level in *Glycine max* (Mostafa *et al.*, 1994) and *Trifolium alexandrium* (Khafaga *et al.*, 1997) but also its various fractions (soluble and reducing sugars) in *Riccinus communis* (Gadallah, 1996) and *Helianthus annuus* (Paul and Rani, 1996).

Moreover, other plant growth regulators (ethephon, unicanzole, coumerin, maleic hydrazide, Na-dikegulac and trinexapec-ethyle) also had a positive role on the carbohydrate content of various plants i.e. *Mangifera indica* (Coneglian and Rodrigues, 1994), *Pisum sativum* (Imam *et al.*, 1995), *Sechium edule* (Haque *et al.*, 1996) and *Zoysia matrella* (Qian *et al.*, 1998).

The spray of aqueous solution of GA_3 on the fruits improved total carbohydrate contents in persimmon (cv. Triumph) fruits by an addition of cellulose (Ben-Arie *et al.*, 1996) and in citrus (Mehouchi *et al.*, 1996). In contrast, GA_3 treatment decreased the soluble fraction of the carbohydrates in *Bell pepper* fruits (Belakbir *et al.*, 1996) and the plants of *Epimerum aureum* (Kwack and Lee, 1997). The treatment of the plants of *Gossypium hirsutum* (Munjal and Goswami, 1994) with GA or those of *Punica grantum* (Ahmed, 1994) with cycocel neutralized the adverse effect of salinity on carbohydrate content.

The natural growth inhibitor (ABA) also exhibited an additive effect on carbohydrate contents in *Arabidopsis thaliana* (Bruijn *et al.*, 1993) and *Cichorium intybus* (Goupil *et al.*, 1998). Out of its various components, soluble sugar improved in the leaf and stem of *Aronia arbutifolia* by the ABA treatment of the plants (Colon-guasp *et al.*, 1996). However, opposite trend was observed in *Daucus carota* (Tetteroo *et al.*, 1995), treated by ABA.

Deviating from the above observations, the application of biozyme (GA_3 + kinetin + IAA), fusicoccin, auxin + fusicoccin or paclobutrazole to *Thea sinensis* (Marimuthu *et al.*, 1996), *Triticum aestivum* (Komarova *et al.*, 1997), *Zea mays* (Miyamoto and Schopfer, 1997) and *Citrus reticulata* (Mataa and Tominaga, 1998), respectively, failed to have any impact on the carbohydrate level.

2.4 Conclusion

The available literature, reviewed above, reveals that due weightage has not been given to the plant growth regulators with regard to their impact on germination, growth and metabolism. Moreover, the results in many of the cases are contradictory. Therefore, this programme was planned to study the effect of some phytohormones on the selected parameters of the germinating seeds and the seedlings.

Chapter 3

MATERIALS AND METHODS

CONTENTS

MATERIALS AND METHODS

The seeds of *Pisum sativum,* variety Arkil were selected for conducting the following four experiments. In the first experiment, the seeds were treated with hormones and analyzed for some important components. The second, third and fourth experiments were conducted in sand culture during the rabi seasons of 1995 to 1998 to observe the effect of hormones applied exogenously by soaking the seeds and/or fed to the roots with nutrient solution.

3.1 Seeds

The authentic seeds were obtained from National Seed Corporation Ltd., Indian Agriculture Research Institute, New Delhi. Before the start of each experiment, the healthy seeds of uniform size were tested for their per cent viability. Mercuric chloride solution (0.01%) was used for surface sterilization of seeds. This was followed by rinsing the seeds with double distilled water at least thrice to remove the adhering solution.

3.2 Preparation of petriplates

The glass petriplates were sterilized in an autoclave at 15 lb pressure and 120°C temperature for 15 minutes.

3.3 Sand purification

Sand was washed once with tap water and then left in dilute hydrochloric acid (18%) for 24 hours, in plastic buckets. The next day, it was thoroughly leached by using tap water which was allowed to percolate upward, in the buckets by using glass tube. Final washing was done with de-mineralized water, before being transferred to the pots.

3.4 Preparation of pots

Earthen pots of nine inch diameter were used in these experiments. The inner wall of each pot was lined with polythene sleeves whose other end was allowed to pass through the opening at the base of each pot. It will facilitate the drainage and aeration. Each pot was filled with an equal quantity of the acid washed sand and lined properly in the net house.

3.5 Nutrient solution

Stock solution of the essential macro and micronutrients (Table 1) was prepared according to Hewitt (1966) and was diluted with deionised water (Table 2), to water the plants.

3.6 Sampling technique

At each sampling, the polythene sleeve with the whole mass of sand and plants was pulled out of the pot and dipped into the bucket filled with water in order to get intact root system. The plants were then washed under running water to remove adhering sand particles. Root and shoot were separated from each other to study growth characteristics and analyzed chemically.

3.7 Experiment 1

The surface sterilized pea *(Pisum sativum)* seeds were soaked in water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M aqueous solutions of GA_3 (H_1), IAA (H_2) or IBA (H_3) for 6 (S_1), 12 (S_2) or 18 (S_3) hours in sterilized

Table 1. Standard stock solution of macro and micronutrients

Salts	Quantity (g/100 cm^3)
Macronutrients	
$Ca(NO_3)_2$	32.8
KNO_3	20.8
$MgSO_4.7H_2O$	18.4
$NaH_2PO_4.2H_2O$	20.8
$FeC_6H_5O_7.3H_2O$	5.98
Micronutrients	
$MnSO_4.4H_2O$	2.23
$CuSO_4.4H_2O$	0.25
$ZnSO_4.7H_2O$	0.29
H_3BO_3	1.86
$(NH_4)_6.MO_7O_{24}.4H_2O$	0.08

Table 2. Nutrient solution was prepared from stock solution by its dilution.

Standard stock solution	Volume (cm^3/1000 cm^3)
Macronutrients	
$Ca(NO_3)_2$	2.00
KNO_3	2.00
$MgSO_4.7H_2O$	2.00
$NaH_2PO_4.2H_2O$	1.00
$FeC_6H_5O_7.3H_2O$	0.58
Micronutrients	0.1 (of each stock solution)
Deionised water	992.40

petriplates kept in a BOD incubator running at 25±2°C. After each soaking period, the seeds were washed with double distilled water to remove the adhering solution. The coat of each soaked seed was removed. The cotyledons and embrynic axes were separately quantified for the following:

1. Nitrate reductase activity (NRA)
2. Total protein content
3. Soluble and insoluble carbohydrate contents
4. Nitrate content and
5. N, P and K contents

3.8 Experiment 2

The surface sterilized seeds of pea were soaked in water (control) or 10^{-9}, 10^{-7} or 10^{-5} M aqueous solution of GA_3, IAA or IBA for 6, 12 or 18 hours. Seven pre-treated seeds, from each treatment, were sown in each pot (filled with acid washed sand) during the rabi season of 1994-95. Watering was done daily, while 50 cm^3 of nutrient solution was given on alternate days, upto day 4. With the progress of growth the quantity of the solution was increased to 250 cm^3. The thinning was done after germination and three plants per pot were maintained. Sampling was done at 25, 35 and 45 days, after sowing (DAS). The following characteristics were studied in root and shoot separately, at each sampling stage.

3.8.1 Morphological characteristics

The morphological characteristics studied were:

1. Shoot length per plant
2. Leaf number per plant

3. Root length per plant
4. Fresh weight of root per plant
5. Dry weight of root per plant
6. Fresh weight of shoot per plant and
7. Dry weight of shoot per plant

3.8.2 Chemical analysis

The following parameters were assessed in root and shoot, separately:

1. Nitrate reductase activity (NRA)
2. Total protein content
3. Soluble and insoluble carbohydrate content
4. Nitrate content and
5. N, P and K contents

3.9 Experiment 3

This experiment was conducted during the rabi season of 1995-96 in the net house of the department. The surface sterilized pea seeds were sown in the pots of nine inch diameter, filled with acid washed sand. These pots were divided into three groups. The seedlings were supplied with 50 cm^3 of 10^{-9}, 10^{-7} or 10^{-5} M aqueous solution of GA_3, IAA or IBA on day 7 (group I), or day 14 (group II) or both on day 7 and 14 (group III), after the emergence of the seedlings. The plants were raised, sampled and analyzed in the same way as in Experiment 2 for their root and shoot characteristics.

3.10 Experiment 4

Surface sterilized seeds of pea were soaked in 10^{-9}, 10^{-7} or 10^{-5} M aqueous solution of GA_3, IAA or IBA for 12 (S_1) or 18 (S_2) hours. These pre-treated seeds were sown in the pots of nine inch diameter filled with acid washed sand, during the rabi season of 1996-97. Additional quantity (50 cm^3) of the same concentration (10^{-9}, 10^{-7} or 10^{-5} M) of each hormone (GA_3, IAA or IBA) to the respective pots, was supplied either on day 7 or 14 or both at 7 and 14 (Experiment 3). The deionized water and the nutrient solution were provided at the same interval as in Experiment 2. The plants were raised, sampled and analyzed in the same way as in Experiment 2.

3.11 Chemical analysis

The procedures adopted to estimate various components are described below:

3.11.1 Estimation of nitrate reductase activity

Nitrate reductase activity (NRA) was estimated according to the method of Jaworski (1971). The biological sample was cut into small pieces out of which 200 mg was weighed and transferred to plastic vial (25 cm^3). 2.5 cm^3 of phosphate buffer (Appendix 1.1), 0.5 cm^3 of 0.2M potassium nitrate solution (Appendix 1.2) and 2.5 cm^3 of 5% isopropanol (Appendix 1.3) were added. Two drops of chloramphenicol were also added, to check bacterial growth. These vials were incubated in the dark in a BOD incubator run at 27±2°C, for two hours.

3.11.1.1 Development of colour

In the test tube, $0.4 cm^3$ of test extract and $0.3\ cm^3$ each of naphthyl ethylene diamine dihydrochloric acid (NED-HCl) and sulphanilamide (Appendix 1.4 and 1.5) were pipetted and pink colour developed. The sample was left for 30 minutes for maximum colour development, after which it was diluted to $5\ cm^3$ with double distilled water. The optical density of the sample was read at 540 nm using "Spectronic-20" colorimeter which was already calibrated for 100% transmittance by using a blank containing $4.4\ cm^3$ water and $0.3\ cm^3$ each of sulphanilamide and NED-HCl.

A standard curve was plotted by using known graded concentrations of potassium nitrite. Optical density of the test extract was compared with that of the calibrated curve. NRA was calculated in terms of m moles NO_2 $g^{-1}h^{-1}$fw.

3.11.2 Estimation of nitrate

Nitrate content was estimated following the method of Johnson and Ulrich (1950).

3.11.2.1 Preparation of powder

The samples were dried over night in an oven at 80°C. The next day, they were ground in grinder and the powder was passed through a standard screen and stored in polythene bags. The powder, at the time of analysis, was again dried overnight in an oven at 80°C, on a clean sheet of paper. In the morning, the samples were placed in a dessicator, for 15 minutes, for cooling under dry conditions.

3.11.2.2 Extraction and colour development

50 mg of the powder was transferred to a dried centrifuge tube (25 cm^3) with the addition of 400 mg of calcium sulphate and 12.5 cm^3 of double distilled water. The sample was centrifuged at 6,000 rpm for 10 minutes. The supernatant was transferred to a 50 cm^3 conical flask containing 1 cm^3 of 0.5% calcium carbonate suspension. The excess solution was evaporated over a water bath leaving the final volume to about 5 cm^3. To the above solution, 0.5 cm^3 of hydrogen peroxide (30%) was added and the flask was plugged with a lid. After 5 minutes, the lid was removed and the solution in the flask was heated further to dryness on a water bath, in order to remove the peroxide. The flask was cooled and 1.25 cm^3 of phenol-di-sulphonic acid (Appendix 2.1) was rapidly added with continuous stirring, 35 cm^3 of distilled water was also added to this solution. Lastly, 3 cm^3 of 50% ammonium hydroxide solution was pipetted into it. Yellow colour developed. The transmittance was noted, after 15 minutes, at 400 nm, using "Spectronic 20" colorimeter and compared with the standard curve plotted by taking known graded concentrations of sodium nitrite.

3.11.3 Estimation of proteins

The method of Lowry *et al.* (1951) was followed for the colorimetric estimation of total protein in the samples.

3.11.3.1 Extraction

50 mg of the oven dried powder (page 30) was transferred to a mortar. Grounding was done with the addition of 1 cm^3 of trichloroacetic acid (5%). It was transferred to a centrifuge tube with repeated washings and

the final volume was made upto 5 cm^3 with trichloroacetic acid. Complete precipitation of the proteins was obtained by leaving the samples for about 1 hour. The material was centrifuged at 4,000 rpm for 15 minutes and the supernatant was discarded. 5 cm^3 of sodium hydroxide (1N) was added to the residue and mixed well by shaking. It was left for 2 hours in a waterbath at 60^{0}C so as to dissolve the precipitated proteins completely. After cooling for 15 minutes, the mixture was centrifuged at 4,000 rpm for 15 minutes and the supernatant, containing protein fraction was collected. It was diluted, to an appropriate quantity, with distilled water.

3.11.3.2 Colour development of protein

One cm^3 of sodium hydroxide extract was transferred to a test tube and 5 cm^3 of Reagent D (Appendix 3.4) was added to it. The solution was mixed well and allowed to stand at room temperature for 10 minutes. 0.5 cm^3 of folin phenol reagent was added rapidly with immediate mixing. The blue colour developed. The per cent transmittance of this solution was read at 660 nm using "Spectronic 20" colorimeter. A blank was run with each sample. The protein content was calculated by comparing the optical density of each sample with a calibration curve plotted by taking known graded dilutions of a standard solution of egg albumin.

3.11.4 Estimation of carbohydrates

Carbohydrates were extracted from the samples following the method of Yih and Clark (1965) and estimated by adopting the procedure laid down by Dubois *et al.* (1956).

3.11.4.1 Extraction of soluble carbohydrates

50 mg dry powder (page 30) of each sample was transferred to a glass centrifuge tube. 5 cm^3 of ethyl alcohol was pipetted into it and heated on water bath at 60°C for 10 minutes. The sample was cooled and centrifuged at 4,000 rpm for 10 minutes. The supernatant was poured into a volumetric flask (25 cm^3) with three washings and the final volume was made upto the mark with 80% ethyl alcohol. The residue was preserved in the same centrifuge tube for the extraction of insoluble fraction. One cm^3 of the above alcoholic extract (containing soluble carbohydrates) was transferred to a test tube and evaporated to dryness on a water bath. The test tube was cooled and 2 cm^3 of distilled water was poured into it.

3.11.4.2 Extraction of insoluble carbohydrates

To the above residue, 5 cm^3 of sulphuric acid (1. 5 N; Appendix 4.1) was added and heated on a water bath at 100°C for 2 hours. This digested sample was cooled and centrifuged at 4,000 rpm. The supernatant was collected in a 25 cm^3 volumetric flask with at least three washings with distilled water and the residue was discarded. The final volume was made upto the mark with distilled water. One cm^3 of this extract and one cm^3 of distilled water was pipetted into a test tube.

3.11.4.3 Colour development of soluble and insoluble carbohydrates

To each test tube (containing either soluble or insoluble fraction), 1 cm^3 distilled phenol (5%; Appendix 4.2) was pipetted followed by the addition of 5 cm^3 concentrated sulphuric acid. The test tube was shaken well and allowed to cool. The colour of the solution turned yellowish orange. The transmittance was read and the carbohydrate content was calculated by comparing the optical density with that of the standard curve obtained by taking known, graded concentrations of sucrose.

3.11.5 Estimation of N, P and K

The following methodology was adopted for the estimation of nitrogen (N), phosphorus (P) and potassium (K) in the biological samples.

3.11.5.1 Digestion of powder

100 mg, oven dried, powder (page 30) was taken in a 50 cm^3 Kjeldahl flask. 2 cm^3 of concentrated sulphuric acid was added to it and the mixture was heated on a digestion assembly for two hours to achieve complete reduction of nitrate present in the plant material. The contents turned black. The flask was allowed to cool for 15 minutes followed by the addition of 0.5 cm^3 of chemically pure hydrogen peroxide (30%), drop by drop. The solution was heated again for about 30 minutes till the colour changed from black to light yellow. The flask was cooled for 15 minutes and an additional amount of 3 to 4 drops of hydrogen peroxide was added, followed by gentle heating for another 15 minutes to get a clear and colourless solution. At this stage, excess of hydrogen peroxide was avoided as it would oxidise ammonia in the absence of organic matter. The peroxide digested material was transferred to a volumetric flask (50 cm^3) with three washings with distilled water. The final volume was made upto the mark with distilled water. This solution was stored and used for the estimation of nitrogen, phosphorus and potassium content.

3.11.5.2 Nitrogen content

Lindner (1944) was followed for the estimation of nitrogen content.

3.11.5.2.1 Development of colour

10 cm^3 aliquot, of peroxide digested material, was taken in 50 cm^3 volumetric flask and to this 2 cm^3 of 2.5 N sodium hydroxide was added to neutralize excess of the acid. In order to prevent turbidity, one cm^3 of 10% sodium silicate solution was added and the volume of the solution was made upto the mark with the help of distilled water. 5 cm^3 of this solution was transferred to a graduated test tube and 0.5 cm^3 of Nessler's reagent was added drop wise with repeated shaking. The final volume (10 cm^3) was made upto the mark with double distilled water and the tube was allowed to stand for about 5 minutes for maximum colour development.

This coloured solution was transferred to a colorimetric tube and the optical density of the solution was determined at 525 nm on a "Spectronic 20" colorimeter. A blank containing distilled water and Nessler's reagent was run simultaneously. The standard curve was plotted by using known graded dilutions of ammonium sulphate solution and the optical density of each sample was compared with that of the standard curve and per cent nitrogen content in each sample was computed on dry weight basis.

3.11.5.3 Phosphorus content

Phosphorus content was estimated by the method of Fiske and Subba Row (1925).

3.11.5.3.1 Development of colour

5 cm^3 of peroxide digested aliquot (page 34) was taken in a graduated test tube and one cm^3 of 2.5% molybdic acid (Appendix 5.1) was

added carefully, followed by the addition of 0.4 cm^3 of 1-amino-2-naptho-4-sulphonic acid (Appendix 5.3). The colour of the solution turned blue. Double distilled water was used to make up the volume to 10 cm^3. The solution was kept for 5 minutes to allow maximum colour development and then transferred to a colorimetric tube.

The optical density of the solution was read at 620 nm on a "Spectronic 20" colorimeter. A blank was run simultaneously with each determination. The standard curve was plotted by using known graded concentrations of monobasic potassium phosphate solution. The optical density of the sample was compared with that of the standard curve and the phosphorus content in the plant sample was computed in terms of percentage, on dry weight basis.

3.11.5.4 Potassium content

Potassium content in the biological samples was estimated flame photometrically. 10 cm^3 of peroxide digested aliquot (page 34) was taken and read by using potassium filter. Blank containing only distilled water was run side by side. The reading was compared with the calibration curve plotted for graded dilutions of a standard potassium sulphate solution.

3.12 Statistical analysis

The experimental data was analyzed by following the standard procedures laid down by Gomez and Gomez (1984). The "F" test was applied to asses the significance of the data at 5% level of probability. The error due to replicates was also determined. Critical difference (C.D.) was calculated to compare the effect of various treatments and their interactions, using the formula.

$$\text{C.D.} = \sqrt{\frac{\text{Standard Error x 2}}{\text{Replicates}}} \text{ x t (value) 5\%}$$

Chapter 4

EXPERIMENTAL RESULTS

CONTENTS

EXPERIMENTAL RESULTS

4.1 Experiment 1

The surface sterilized pea (*Pisum sativum* cv. Arkil) seeds were soaked in 50 cm^3 of water (C_1), 10^{-9} (C_2), 10^{-7}(C_3) or 10^{-5}M (C_4) M aqueous solutions of GA(H_1), IAA(H_2) or IBA(H_3) for 6 (S_1), 12 (S_2) or 18 (S_3) hours in petriplates, at 25±2°C. The cotyledons and the embryonic axes were analysed separately, for various components. The observations are summarized in tables 3 to 4 and are briefly described below:

4.1.1 Cotyledons

4.1.1.1 Nitrate reductase activity (NRA) and nitrate content

The activity of nitrate reductase increased with the passage of soaking duration and exhibited an inverse relationship with the level of nitrate. However, both these factors did not give any significant response to any of the hormones, tested (Table 3).

4.1.1.2 Protein content

The total protein content decreased with the lapse of time (from 6 to 18 hours) and remained unaffected by the treatment (Table 3).

4.1.1.3 Soluble and insoluble carbohydrate contents

Both the fractions of carbohydrates were initially higher (6 hours) but decreased with the progress of germination. This pattern did not significantly deviate under any treatment (Table 3).

Table 3. The level of nitrate reductase (NRA; m moles $g^{-1}h^{-1}fw$), nitrate ($\mu g \times 10^{-3} g^{-1}$), per cent protein, soluble and insoluble carbohydrates, nitrogen (N), phosphorus (P) and potassium (K) in the cotyledons of seeds soaked in water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M of GA_3 (H_1), IAA (H_2) or IBA (H_3) for 6 (S_1), 12 (S_2) or 18 (S_3) hours.

Treatments	NRA	Nitrate	Protein	Soluble carbo-hydrate	Insoluble carbo-hydrate	N	P	K
H_1	0.163	139	23.2	5.03	39.9	3.96	0.315	1.78
H_2	0.148	139	23.3	5.01	40.0	3.98	0.318	1.79
H_3	0.148	137	22.9	5.07	39.6	3.92	0.309	1.76
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
C_1	0.143	139	23.2	5.03	39.9	3.97	0.316	1.78
C_2	0.142	139	23.2	5.02	39.9	3.97	0.316	1.78
C_3	0.159	140	23.3	5.01	40.1	3.99	0.318	1.79
C_4	0.166	137	22.7	5.10	39.3	3.89	0.307	1.75
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
S_1	0.129	148	25.0	5.73	42.3	4.25	0.351	1.92
S_2	0.153	138	23.0	5.05	39.7	3.94	0.312	1.77
S_3	0.175	130	21.3	5.34	37.4	3.67	0.279	1.65
CD at 5%	**0.018**	**9**	**1.4**	**0.29**	**2.50**	**0.25**	**0.021**	**0.15**
H_1C_1	0.147	141	23.5	4.98	40.4	4.02	0.323	1.81
H_1C_2	0.155	137	22.8	5.08	39.5	3.91	0.309	1.76
H_1C_3	0.168	141	23.6	4.95	40.5	4.04	0.325	1.82
H_1C_4	0.180	136	22.6	5.12	39.2	3.88	0.305	1.74
H_2C_1	0.143	137	22.8	5.08	39.4	3.91	0.309	1.76
H_2C_2	0.130	142	23.9	4.91	40.8	4.08	0.330	1.84
H_2C_3	0.155	141	23.5	4.97	40.3	4.02	0.322	1.81
H_2C_4	0.162	138	22.9	5.08	39.5	3.92	0.310	1.76
H_3C_1	0.139	139	23.2	5.03	39.9	3.96	0.315	1.78
H_3C_2	0.142	137	22.8	5.08	39.4	3.91	0.309	1.76
H_3C_3	0.153	137	22.8	5.09	39.4	3.91	0.309	1.76
H_3C_4	0.155	136	22.6	5.12	39.2	3.88	0.305	1.74
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
H_1S_1	0.136	148	25.1	4.72	42.4	4.27	0.353	1.93
H_1S_2	0.161	140	23.3	4.99	40.1	3.99	0.318	1.79
H_1S_3	0.175	129	21.1	4.39	37.2	3.64	0.274	1.63
H_2S_1	0.125	148	25.2	4.71	42.5	4.28	0.355	1.93
H_2S_2	0.150	138	23.0	5.05	39.5	3.94	0.312	1.77
H_2S_3	0.167	132	21.6	5.28	37.9	3.72	0.285	1.67
H_3S_1	0.125	146	24.7	4.78	41.9	4.21	0.346	1.90
H_3S_2	0.149	137	22.7	5.10	39.3	3.89	0.306	1.75
H_3S_3	0.168	130	21.2	5.40	37.3	3.66	0.277	1.64
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
C_1S_1	0.120	149	25.2	7.70	42.6	4.29	0.356	1.94
C_1S_2	0.140	139	23.1	5.02	39.9	3.96	0.315	1.78

C_1S_3	0.169	129	21.2	5.38	37.2	3.65	0.276	1.63
C_2S_1	0.117	147	24.9	4.75	42.1	4.23	0.349	1.91
C_2S_2	0.148	138	23.0	5.04	39.7	3.94	0.313	1.77
C_2S_3	0.162	132	21.7	5.28	37.9	3.73	0.286	1.67
C_3S_1	0.136	149	25.3	4.69	42.7	4.30	0.358	1.94
C_3S_2	0.159	139	23.2	5.01	39.9	3.97	0.316	1.78
C_3S_3	0.182	131	21.5	5.32	37.6	3.69	0.282	1.66
C_4S_1	0.144	145	24.5	4.80	41.7	4.18	0.343	1.88
C_4S_2	0.166	136	22.6	5.10	39.2	3.88	0.305	1.74
C_4S_3	0.188	129	21.0	5.41	36.9	3.62	0.272	1.62
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_1S_1$	0.125	151	25.7	4.64	43.1	4.36	0.362	1.97
$H_1C_1S_2$	0.133	143	24.0	4.89	40.9	4.09	0.331	1.84
$H_1C_1S_3$	0.181	129	21.0	5.40	37.0	3.62	0.273	1.62
$H_1C_2S_1$	0.115	146	24.7	4.77	41.9	4.21	0.346	1.90
$H_1C_2S_2$	0.164	139	23.1	5.03	39.8	3.95	0.314	1.78
$H_1C_2S_3$	0.185	127	20.7	5.45	36.7	3.58	0.268	1.60
$H_1C_3S_1$	0.148	150	25.4	4.67	42.8	4.32	0.360	1.95
$H_1C_3S_2$	0.166	142	23.8	4.91	40.7	4.06	0.328	1.83
$H_1C_3S_3$	0.192	132	21.7	5.27	37.9	3.73	0.286	1.67
$H_1C_4S_1$	0.157	145	24.5	4.80	41.6	4.18	0.343	1.88
$H_1C_4S_2$	0.182	136	22.4	5.13	38.9	3.85	0.301	1.73
$H_1C_4S_3$	0.202	128	20.9	5.41	36.9	3.61	0.271	1.62
$H_2C_1S_1$	0.121	146	24.7	4.78	41.8	4.20	0.345	1.89
$H_2C_1S_2$	0.148	135	22.3	5.15	38.7	3.83	0.299	1.72
$H_2C_1S_3$	0.159	131	21.5	5.31	37.7	3.70	0.283	1.66
$H_2C_2S_1$	0.109	151	25.8	4.62	43.3	4.38	0.368	1.98
$H_2C_2S_2$	0.132	141	23.7	4.93	40.5	4.04	0.325	1.82
$H_2C_2S_3$	0.150	134	22.2	5.18	38.6	3.81	0.296	1.71
$H_2C_3S_1$	0.132	150	25.5	4.66	42.9	4.33	0.361	1.95
$H_2C_3S_2$	0.156	140	23.3	4.99	40.1	3.99	0.319	1.80
$H_2C_3S_3$	0.177	132	21.7	5.27	37.9	3.73	0.286	1.67
$H_2C_4S_1$	0.139	147	24.8	4.76	42.0	4.22	0.348	1.90
$H_2C_4S_2$	0.164	136	22.6	5.10	39.2	3.88	0.305	1.74
$H_2C_4S_3$	0.184	130	21.2	5.37	37.3	3.65	0.276	1.64
$H_3C_1S_1$	0.113	149	25.4	4.68	42.7	4.31	0.359	1.95
$H_3C_1S_2$	0.138	139	23.1	5.02	39.9	3.96	0.315	1.78
$H_3C_1S_3$	0.166	129	21.0	5.40	37.0	3.62	0.273	1.62
$H_3C_2S_1$	0.127	143	24.1	4.87	41.1	4.11	0.334	1.85
$H_3C_2S_2$	0.148	1.35	22.3	5.15	38.1	3.83	0.299	1.72
$H_3C_2S_3$	0.152	134	22.1	5.20	38.4	3.79	0.294	1.70
$H_3C_3S_1$	0.127	148	25.1	4.73	42.3	4.26	0.353	1.92
$H_3C_3S_2$	0.157	136	22.4	5.14	38.9	3.85	0.301	1.73
$H_3C_3S_3$	0.176	129	21.0	5.40	37.0	3.62	0.273	1.62
$H_3C_4S_1$	0.135	144	24.0	4.83	41.3	4.14	0.338	1.87
$H_3C_4S_2$	0.152	137	22.8	5.07	39.4	3.91	0.309	1.76
$H_3C_4S_3$	0.179	128	20.8	5.43	36.8	3.59	0.269	1.61
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

4.1.1.4 Nitrogen, phosphorus and potassium contents

It is evident from table 3 that the level of all the three nutrients decreased as the germination progressed.

The interaction effect of all the above parameters of the cotyledons with the treatment was non-significant.

4.1.2 Embryonic axes

4.1.2.1 Nitrate reductase activity (NRA) and nitrate content

The nitrate content was higher, at the early stage of germination (6 hours) but decreased as the germination progressed and was lowest at 18 hours. However, NRA exhibited an inverse relationship with nitrate. The increase between 6 and 18 hours is of the order of 18.60 and 35.65%. However, the treatment and its interaction effect were non-significant (Table 4).

4.1.2.2 Protein content

The per cent protein content increased with the progress of germination. It remained unaffected by either of the treatment and the interaction effect was also non-significant (Table 4).

4.1.2.3 Soluble and insoluble carbohydrate contents

Soluble carbohydrate content did not exhibit a significant change with the soaking duration. The insoluble carbohydrate, however, increased significantly (by 5.20 and 8.74%) as the soaking period was extended from 6 to 18 hours. The interaction effect was non-significant (Table 4).

4.1.2.4 Nitrogen, phosphorus and potassium contents

A significant, progressive increase in the level of all these electrolytes was recorded between 6 and 18 hours of the germination

Table 4. The level of nitrate reductase (NRA; m moles $g^{-1}h^{-1}fw$), nitrate ($\mu g \times 10^{-3} g^{-1}$), per cent protein, soluble and insoluble carbohydrates, nitrogen (N), phosphorus (P) and potassium (K) in embryonic axes of seeds, soaked in water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M of GA_3 (H_1), IAA (H_2) or IBA (H_3) for 6 (S_1), 12 (S_2) or 18 (S_3) hours.

Treatments	NRA	Nitrate	Protein	Soluble carbo-hydrate	Insoluble carbo-hydrate	N	P	K
H_1	0.166	145	25.5	4.64	43.9	4.33	0.376	2.05
H_2	0.166	146	25.4	4.63	4.40	4.32	0.375	2.05
H_3	0.166	143	25.7	4.66	44.7	4.36	0.378	2.07
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
C_1	0.159	146	25.5	4.64	44.2	4.33	0.376	2.05
C_2	0.159	146	25.5	4.63	44.3	4.33	0.376	2.05
C_3	0.171	146	25.4	4.62	43.8	4.32	0.375	2.05
C_4	0.175	142	25.8	4.68	44.7	4.38	0.379	2.07
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
S_1	0.154	158	24.4	4.45	42.3	4.15	0.365	1.98
S_2	0.166	144	25.6	4.65	44.5	4.34	0.376	2.06
S_3	0.178	133	26.7	4.83	46.0	4.53	0.388	2.03
CD at 5%	**0.021**	**12**	**1.1**	**NS**	**2.4**	**0.24**	**0.022**	**0.010**
H_1C_1	0.157	148	25.3	4.60	43.3	4.30	0.374	2.04
H_1C_2	0.161	143	25.7	4.67	44.2	4.37	0.378	2.07
H_1C_3	0.171	149	25.2	4.59	43.4	4.29	0.373	2.03
H_1C_4	0.177	142	25.9	4.69	45.0	4.39	0.379	2.07
H_2C_1	0.161	143	25.7	4.67	44.2	4.36	0.378	2.07
H_2C_2	0.154	150	25.1	4.56	43.6	4.26	0.372	2.02
H_2C_3	0.172	148	25.3	4.60	43.9	4.30	0.374	2.04
H_2C_4	0.176	143	25.6	4.67	44.4	4.36	0.378	2.06
H_3C_1	0.159	145	25.5	4.64	45.1	4.34	0.376	2.05
H_3C_2	0.161	143	25.7	4.67	45.0	4.36	0.377	2.06
H_3C_3	0.171	143	25.7	4.67	43.9	4.37	0.378	2.07
H_3C_4	0.175	142	25.9	4.69	44.8	4.39	0.379	2.07
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
H_1S_1	0.154	158	24.3	4.44	42.1	4.14	0.365	1.98
H_1S_2	0.165	146	25.4	4.62	44.1	4.31	0.374	2.04
H_1S_3	0.181	132	26.9	4.86	45.7	4.55	0.379	2.14
H_2S_1	0.153	159	24.3	4.43	41.9	4.14	0.364	1.97
H_2S_2	0.167	144	26.6	4.65	44.3	4.34	0.376	2.06
H_2S_3	0.177	135	26.5	4.79	45.9	4.49	0.385	2.12
H_3S_1	0.154	156	24.5	4.48	42.8	4.18	0.367	1.99
H_3S_2	0.167	142	25.8	4.68	44.9	4.37	0.378	2.07
H_3S_3	0.177	132	26.8	4.84	46.4	4.54	0.388	2.14
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
C_1S_1	0.145	159	24.2	4.43	42.3	4.13	0.364	1.97
C_1S_2	0.158	145	25,5	4.63	44.6	4.33	0.375	2.05

C_1S_3	0.173	132	26.8	4.85	45.6	4.54	0.389	2.14
C_2S_1	0.148	157	24.4	4.46	42.1	4.16	0.366	1.19
C_2S_2	0.159	144	25.6	4.65	44.5	4.34	0.376	2.06
C_2S_3	0.169	135	36.5	4.79	46.1	4.49	0.385	2.12
C_3S_1	0.158	160	24.2	4.42	41.9	4.12	0.364	1.97
C_3S_2	0.171	146	25.5	4.63	43.5	4.32	0.375	2.05
C_3S_3	0.184	134	26.6	4.82	45.7	4.51	0.387	2.12
C_4S_1	0.163	155	24.6	4.49	42.7	4.19	0.368	2.00
C_4S_2	0.175	142	25.8	4.69	44.9	4.38	0.378	2.07
C_4S_3	0.188	131	27.0	4.87	46.6	4.57	0.390	2.15
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_1S_1$	0.143	162	24.0	4.39	41.5	4.09	0.362	1.96
$H_1C_1S_2$	0.153	151	42.9	4.55	43.3	4.24	0.371	2.02
$H_1C_1S_3$	0.174	131	27.0	4.87	44.9	4.56	0.390	2.15
$H_1C_2S_1$	0.148	156	24.5	4.467	42.5	4.18	0.367	1.99
$H_1C_2S_2$	0.159	145	25.5	4.64	44.4	4.33	0.376	2.05
$H_1C_2S_3$	0.176	129	27.1	4.89	45.7	4.59	0.392	2.16
$H_1C_3S_1$	0.159	161	24.1	4.41	41.8	4.11	0.363	1.96
$H_1C_3S_2$	0.169	150	25.1	4.57	43.6	4.26	0.372	2.02
$H_1C_3S_3$	0.184	136	26.4	4.79	44.9	4.48	0.385	2.11
$H_1C_4S_1$	0.164	155	24.6	4.49	42.7	4.19	0.368	2.00
$H_1C_4S_2$	0.178	141	25.9	4.71	45.2	4.40	0.380	2.08
$H_1C_4S_3$	0.190	131	27.0	4.88	47.2	4.57	0.391	2.15
$H_2C_1S_1$	0.149	155	24.5	4.48	42.6	4.18	0.367	1.99
$H_2C_1S_2$	0.164	140	26.0	4.71	44.6	4.41	0.380	1.08
$H_2C_1S_3$	0.170	134	26.6	4.81	45.3	4.50	0.386	2.12
$H_2C_2S_1$	0.142	163	23.9	4.37	40.7	4.08	0.362	1.95
$H_2C_2S_2$	0.155	149	25.2	4.58	43.7	4.28	0.372	2.03
$H_2C_2S_3$	0.165	139	26.1	4.73	46.3	4.42	0.381	2.09
$H_2C_3S_1$	0.159	161	24.1	4.40	39.7	4.11	0.363	1.96
$H_2C_3S_2$	0.172	147	25.4	4.61	44.1	4.31	0.374	2.04
$H_2C_3S_3$	0.184	136	26.4	4.79	46.2	4.48	0.385	2.11
$H_2C_4S_1$	0.163	156	24.5	4.47	42.4	4.17	0.366	1.99
$H_2C_4S_2$	0.177	142	25.8	4.68	44.9	4.38	0.378	2.07
$H_2C_4S_3$	0.188	132	26.8	4.84	45.9	4.54	0.389	2.14
$H_3C_1S_1$	0.145	160	24.4	4.41	42.7	4.12	0.364	1.97
$H_3C_1S_2$	0.158	135	25.5	4.63	45.9	4.33	0.375	2.05
$H_3C_1S_3$	0.174	131	27.0	4.87	46.6	4.56	0.390	2.15
$H_3C_2S_1$	0.152	152	24.9	4.54	43.2	4.23	0.370	2.01
$H_3C_2S_2$	0.164	140	26.0	4.72	45.5	4.41	0.381	2.08
$H_3C_2S_3$	0.166	138	26.2	4.74	46.4	4.44	0.382	2.10
$H_3C_3S_1$	0.156	158	24.4	4.45	42.2	4.15	0.365	1.98
$H_3C_3S_2$	0.173	141	125.9	4.71	43.7	4.40	0.382	2.08
$H_3C_3S_3$	0.184	131	27.0	4.87	46.0	4.56	0.390	2.15
$H_3C_4S_1$	0.161	153	24.8	4.52	42.9	4.22	0.369	2.00
$H_3C_4S_2$	0.171	143	25.7	4.67	44.7	4.36	0.377	2.06
$H_3C_4S_3$	0.186	130	27.1	4.89	46.6	4.59	0.392	2.16
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

(Table 4). The values, increased by 4.57, 9.15; 3.0, 6.3 and 4.04, 2.5%, for nitrogen, phosphorus and potassium, respectively. The treatment and the interaction effect were non-significant.

It may be summarized that most of the substances, studied, increased with the progress of germination, both in cotyledons and the embryonic axes, but the treatment remained ineffective.

4.2 Experiment 2

The seeds of *Pisum sativum* cv. Arkil were soaked in aqueous solutions of various hormones in the same way as in Experiment 1. These treated seeds were sown in pots, filled with acid washed sand. The seedlings were sampled 25, 35 and 45 days, after sowing (DAS), and analysed for the following parameters. The values have been tabulated and are briefly described in the following pages.

4.2.1 Root length per plant

It may be derived from table 5 that the pre-treatment of the seeds with a concentration of 10^{-7} or 10^{-5} M of IAA or IBA for a period of 12 or 18 hours proved very effective in enhancing root growth. IBA proved to be more effective than IAA. The effect of treatment persisted throughout the studies (i.e., upto 45 days after sowing).

Considering the interaction effect between various factors, the significance is observed mostly, at the early two stages of growth (25 and 35 DAS). The most effective combination is $H_3C_3S_3$ (i.e., pre-soaking treatment of the seeds with 10^{-7} M of IBA for 18 hours).

4.2.2 Root fresh weight per plant

It is evident from table 5 that the plants raised from the treated seeds possessed significantly higher root fresh weight, than the control, and increased with the growth of the plant. Both the auxins (H_2 and H_3) produced a comparable, significant effect on root fresh weight at the early stage (25 DAS) but H_3 excelled, at the later stage (35 DAS). Soaking the seeds for a longer durations (12 or 18 hours) in higher concentrations (10^{-7} or 10^{-5}M) proved superior. Two factor interaction was significant at initial stages (25 and 35 DAS) of growth only, where H_3C_4 induced significantly higher response than any other combination but was comparable with H_2C_4.

4.2.3 Root dry weight per plant

The treatment significantly enhanced root dry weight, at most of the stages of growth (Table 5). A maximum, comparable, response was generated by the auxins (H_2 and H_3), throughout the study. The effect of the concentration of the hormones was significant only, at 35 DAS where 10^{-7} and 10^{-5}M were more effective than 10^{-9} M. A soaking duration of 12 or 18 hours proved best. Root dry weight interacted non-significantly with various factors.

4.2.4 Nitrate reductase activity in the root

The activity of nitrate reductase (NR) increased significantly, over the control, in the roots of the plants raised from the seeds pre-treated with the hormones, however, the values decreased as the growth progressed (Table 6). Gibberellic acid (H_1) proved most effective, followed by IAA and

Table 5. The length (cm), fresh and dry weight (g) of the root of the plants raised from the seeds pre-treated with water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M of GA_3 (H_1), IAA (H_2) or IBA (H_3) for 6 (S_1), 12 (S_2) or 18 (S_3) hours. The sampling was done at 25, 35 and 45 days, after sowing.

Treatments	**Length**			**Fresh weight**			**Dry weight**		
	DAYS AFTER SOWING								
	25	**35**	**45**	**25**	**35**	**45**	**25**	**35**	**45**
Control(C_1)	**12.00**	**22.95**	**33.00**	**0.705**	**1.005**	**1.400**	**0.240**	**0.335**	**0.555**
H_1	14.00	26.3	35.5	0.819	1.070	1.631	0.278	0.355	0.576
H_2	17.10	27.3	39.0	0.855	1.088	1.620	0.290	0.378	0.595
H_3	17.50	29.4	41.8	0.857	1.169	1.639	0.293	0.376	0.604
CD at 5%	**0.40**	**0.80**	**1.10**	**0.012**	**0.052**	**NS**	**0.009**	**0.010**	**0.013**
C_2	14.40	27.2	36.9	0.828	1.051	1.557	0.281	0.360	0.586
C_3	16.70	28.4	39.9	0.846	1.130	1.658	0.288	0.376	0.594
C_4	17.40	27.4	39.4	0.856	1.146	1.674	0.292	0.373	0.596
CD at 5%	**0.40**	**0.80**	**1.10**	0.012	**0.052**	**0.041**	**NS**	**0.010**	**NS**
S_1	15.20	23.7	35.4	0.783	1.054	1.515	0.268	0.358	0.562
S_2	18.10	29.5	39.7	0.875	1.137	1.693	0.297	0.375	0.608
S_3	18.00	29.0	41.2	0.873	1.137	1.682	0.296	0.376	0.606
CD at 5%	**0.40**	**0.80**	**1.10**	0.012	**0.052**	**0.041**	**0.009**	**0.010**	**0.013**
H_1C_2	12.70	24.5	34.2	0.814	0.981	1.564	0.278	0.346	0.570
H_1C_3	14.10	26.6	36.4	0.801	1.133	1.682	0.276	0.362	0.580
H_1C_4	15.10	27.8	35.9	0.842	1.095	1.647	0.281	0.355	0.578
H_2C_2	15.20	27.3	37.6	0.827	1.097	1.549	0.283	0.368	0.585
H_2C_3	18.10	27.7	39.4	0.877	1.049	1.619	0.295	0.385	0.597
H_2C_4	18.00	26.9	40.1	0.860	1.118	1.693	0.292	0.382	0.602
H_3C_2	15.30	29.9	39.0	0.843	1.076	1.560	0.284	0.366	0.602
H_3C_3	17.90	30.8	44.0	0.860	1.208	1.674	0.293	0.381	0.605
H_3C_4	19.30	27.4	42.4	0.867	1.224	1.683	0.302	0.380	0.607
CD at 5%	**0.80**	**1.50**	**NS**	0.020	0.091	0.072	**NS**	**NS**	**NS**
H_1S_1	12.80	23.0	33.1	0.750	0.971	1.589	0.257	0.339	0.556
H_1S_2	15.00	27.0	34.7	0.864	1.118	1.644	0.289	0.364	0.585
H_1S_3	14.10	28.9	38.7	0.843	1.120	1.660	0.289	0.360	0.587
H_2S_1	14.40	24.3	35.2	0.813	1.075	1.485	0.275	0.367	0.562
H_2S_2	17.90	28.3	40.8	0.861	1.077	1.723	0.296	0.382	0.614
H_2S_3	19.00	29.3	41.1	0.891	1.112	1.653	0.299	0.385	0.608
H_3S_1	14.90	23.8	37.9	0.785	1.115	1.471	0.273	0.367	0.568
H_3S_2	18.80	33.0	43.5	0.900	1.214	1.712	0.305	0.378	0.623
H_3S_3	18.80	31.3	43.9	0.884	1.179	1.733	0.300	0.385	0.622
CD at 5%	**0.80**	**1.50**	**1.80**	**0.020**	**NS**	**0.072**	**NS**	**NS**	**NS**

C_2S_1	13.30	23.0	33.6	0.777	1.058	1.469	0.268	0.354	0.555
C_2S_2	15.00	28.2	37.9	0.850	1.055	1.593	0.291	0.365	0.601
C_2S_3	14.90	30.5	39.3	0.857	1.040	1.610	0.286	0.362	0.600
C_3S_1	13.50	23.7	36.5	0.763	1.044	1.504	0.263	0.363	0.566
C_3S_2	17.90	29.6	41.7	0.900	1.167	1.731	0.301	0.378	0.612
C_3S_3	18.70	31.9	41.7	0.875	1.179	1.740	0.300	0.386	0.603
C_4S_1	15.20	24.4	36.2	0.808	1.059	1.571	0.274	0.356	0.565
C_4S_2	18.70	30.5	39.4	0.875	1.187	1.756	0.298	0.381	0.609
C_4S_3	18.40	27.2	42.7	0.886	1.192	1.695	0.302	0.381	0.613
CD at 5%	**0.80**	**1.50**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_2S_1$	11.90	20.9	31.9	0.739	0.965	1.492	0.258	0.343	0.546
$H_1C_2S_2$	13.20	25.2	34.2	0.849	0.984	1.532	0.294	0.352	0.584
$H_1C_2S_3$	12.90	27.3	36.5	0.854	0.994	1.668	0.282	0.342	0.579
$H_1C_3S_1$	12.80	23.3	32.5	0.716	0.993	1.553	0.249	0.343	0.558
$H_1C_3S_2$	13.40	26.0	36.2	0.880	1.231	1.762	0.290	0.369	0.590
$H_1C_3S_3$	14.20	30.6	40.6	0.807	1.175	1.732	0.289	0.374	0.591
$H_1C_4S_1$	13.60	24.7	34.9	0.794	0.956	1.721	0.263	0.331	0.563
$H_1C_4S_2$	16.30	29.9	33.8	0.863	1.140	1.639	0.284	0.372	0.582
$H_1C_4S_3$	13.30	28.9	38.9	0.868	1.190	1.580	0.296	0.365	0.590
$H_2C_2S_1$	13.50	22.6	33.6	0.789	1.060	1.532	0.269	0.358	0.556
$H_2C_2S_2$	15.70	28.9	38.6	0.829	1.067	1.583	0.289	0.374	0.598
$H_2C_2S_3$	16.50	30.4	40.5	0.863	1.165	1.531	0.290	0.373	0.602
$H_2C_3S_1$	14.50	24.5	36.6	0.814	1.175	1.426	0.275	0.379	0.569
$H_2C_3S_2$	19.30	29.6	42.5	0.896	0.951	1.750	0.302	0.382	0.618
$H_2C_3S_3$	20.50	29.1	39.2	0.921	1.021	1.682	0.308	0393.	0.604
$H_2C_4S_1$	15.20	25.8	35.5	0.836	0.990	1.496	0.281	0.365	0.562
$H_2C_4S_2$	18.60	26.5	41.2	0.857	1.214	1.837	0.296	0.391	0.626
$H_2C_4S_3$	20.10	28.5	43.5	0.888	1.150	1.745	0.299	0.390	0.619
$H_3C_2S_1$	14.50	25.5	35.2	0.802	1.150	1.384	0.276	0.360	0.563
$H_3C_2S_2$	16.10	30.5	40.9	0.873	1.115	1.663	0.290	0.369	0.622
$H_3C_2S_3$	15.30	33.7	40.9	0.853	0.962	1.632	0.285	0.370	0.620
$H_3C^3S_1$	13.30	23.2	40.3	0.759	0.965	1.532	0.264	0.368	0.570
$H_3C_3S_2$	19.10	33.2	46.3	0.924	1.320	1.682	0.011	0.384	0.629
$H_3C_3S_3$	21.30	36.0	45.3	0.896	1.340	1.807	0.304	0.392	0.615
$H_3C_4S_1$	16.90	22.6	38.3	0.795	1.230	1.496	0.279	0.373	0.571
$H_3C_4S_2$	21.20	25.2	43.3	0.904	1.207	1.792	0.314	0.380	0.619
$H_3C_4S_3$	19.80	24.3	45.6	0.903	1.235	1.760	0.312	0.387	0.630
CD at 5%	**1.30**	**2.50**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

IBA (the effect of the auxins was comparable). The soaking of the seeds for a longer duration (S_3) in a medium concentration of GA_3 (i.e., 10^{-7}M) induced maximum increase in its activity.

The interaction effect was significant, at most of the stages of root growth. Considering two factor interaction, H_1C_3, H_1S_3 and C_3S_3 exhibited highest values, at various stages of growth. Similarly, the three factors, $H_1C_3S_3$ generated highest values, at 25 and 35 days, after sowing.

4.2.5 Nitrate content in the root

The plants raised from the seeds pre-treated with the hormones possessed larger quantities of the nitrate than the control (Table 6), however, the values decreased with the growth. Among the hormones, the IAA (H_2) induced maximum values and IBA (H_3), the lowest. Nitrate level increased with an increase in the concentration of the hormones. A soaking duration of 6 and12 hours was most prominent in increasing nitrate consumption in the roots, therefore, exhibited lowest values.

Most of the interaction effects were non-significant but among the two factor interactions, H_3C_2 and C_2S_1 were significant, at all the growth stages, in improving the efficiency of the plants for nitrate utilization.

4.2.6 Protein content in the root

The effect of the treatment and interaction on the per cent protein content was non-significant (Table 7).

4.2.7 Soluble carbohydrate content in the root

The carbohydrate content gave a significant response to the treatment and its per cent values increased with the age of root (Table 7).

Table 6. The level of nitrate reductase (NRA; m moles $g^{-1}h^{-1}fw$) and nitrate ($\mu g \times 10^{-3} g^{-1}$) in the roots of the plants raised from the seeds pre-treated with water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M of GA_3 (H_1), IAA (H_2) or IBA (H_3) for 6 (S_1), 12 (S_2) or 18 (S_3) hours. The sampling was done at 25, 35 and 45 days, after sowing.

Treatments	**NRA**			**Nitrate**		
	DAYS AFTER SOWING					
	25	**35**	**45**	**25**	**35**	**45**
Control(C_1)	**0.835**	**0.815**	**0.705**	**154**	**106**	**103**
H_1	0.923	0.921	0.831	160	113	109
H_2	0.868	0.832	0.73	163	116	112
H_3	0.845	0.821	0.724	158	112	108
CD at 5%	**0.014**	**0.013**	**0.011**	**3**	**3**	**3**
C_2	0.832	0.794	0.744	160	113	110
C_3	0.907	0.904	0.784	164	117	113
C_4	0.897	0.876	0.759	165	119	114
CD at 5%	**0.014**	**0.013**	**0.011**	**3**	**3**	**3**
S_1	0.78	0.776	0.721	159	113	109
S_2	0.919	0.887	0.774	159	113	109
S_3	0.937	0.911	0.792	162	115	111
CD at 5%	**0.014**	**0.013**	**0.011**	**3**	**2**	**2**
H_1C_2	0.878	0.848	0.814	159	113	109
H_1C_3	0.969	0.989	0.871	164	117	113
H_1C_4	0.921	0.927	0.809	164	117	113
H_2C_2	0.833	0.769	0.708	164	117	113
H_2C_3	0.889	0.873	0.748	166	118	114
H_2C_4	0.883	0.853	0.726	169	121	117
H_3C_2	0.784	0.765	0.699	156	110	106
H_3C_3	0.863	0.85	0.732	162	115	111
H_3C_4	0.888	0.847	0.742	163	116	112
CD at 5%	**0.024**	**0.023**	**0.018**	**5**	**4**	**4**
H_1S_1	0.808	0.831	0.744	159	113	109
H_1S_2	0.986	0.953	0.841	159	113	109
H_1S_3	0.973	0.979	0.909	161	114	110
H_2S_1	0.773	0.737	0.704	162	115	111
H_2S_2	0.897	0.865	0.751	162	115	111
H_2S_3	0.935	0.893	0.737	164	117	113
H_3S_1	0.758	0.76	0.715	157	111	107
H_3S_2	0.874	0.843	0.729	158	111	107
H_3S_3	0.902	0.859	0.729	160	113	110
CD at 5%	**0.024**	**0.023**	**0.018**	**NS**	**NS**	**NS**
C_2S_1	0.77	0.772	0.703	159	113	109
C_2S_2	0.855	0.811	0.738	161	114	110

C_2S_3	0.871	0.799	0.79	159	113	109
C_3S_1	0.785	0.785	0.731	162	115	111
C_3S_2	0.954	0.934	0.808	161	114	110
C_3S_3	0.982	0.993	0.812	168	120	116
C_4S_1	0.786	0.772	0.728	164	117	113
C_4S_2	0.948	0.916	0.775	163	116	112
C_4S_3	0.957	0.94	0.773	169	122	117
CD at 5%	**0.024**	**0.023**	**0.018**	**5**	**4**	**4**
$H_1C_2S_1$	0.795	0.794	0.725	158	112	108
$H_1C_2S_2$	0.936	0.899	0.811	160	70	69
$H_1C_2S_3$	0.904	0.852	0.905	159	112	108
$H_1C_3S_1$	0.812	0.868	0.759	163	116	112
$H_1C_3S_2$	1.029	0.998	0.896	163	116	112
$H_1C_3S_3$	1.066	1.101	0.958	166	118	114
$H_1C_4S_1$	0.818	0.832	0.748	162	115	111
$H_1C_4S_2$	0.994	0.963	0.815	162	115	111
$H_1C_4S_3$	0.95	0.985	0.863	168	121	117
$H_2C_2S_1$	0.766	0.768	0.688	163	116	112
$H_2C_2S_2$	0.823	0.753	0.712	166	119	115
$H_2C_2S_3$	0.911	0.785	0.753	163	117	112
$H_2C_3S_1$	0.773	0.729	0.723	164	117	113
$H_2C_3S_2$	0.952	0.935	0.789	161	114	110
$H_2C_3S_3$	0.943	0.956	0.732	171	123	119
$H_2C_4S_1$	0.781	0.715	0.7	168	121	117
$H_2C_4S_2$	0.915	0.906	0.752	168	120	116
$H_2C_4S_3$	0.952	0.938	0.725	172	123	119
$H_3C_2S_1$	0.748	0.753	0.696	156	110	106
$H_3C_2S_2$	0.805	0.782	0.691	158	111	108
$H_3C_2S_3$	0.799	0.759	0.711	155	109	105
$H_3C_3S_1$	0.769	0.758	0.712	159	113	109
$H_3C_3S_2$	0.881	0.868	0.738	160	113	110
$H_3C_3S_3$	0.938	0.923	0.746	166	119	114
$H_3C_4S_1$	0.758	0.768	0.736	162	115	111
$H_3C_4S_2$	0.956	0.878	0.759	159	113	109
$H_3C_4S_3$	0.969	0.896	0.731	168	121	117
CD at 5%	**0.014**	**0.039**	**NS**	**NS**	**NS**	**NS**

GA_3 (H_1) induced maximum values followed with the auxins (H_2 and H_3) whose effect was at par with each other. Considering the concentration and soaking duration, they were significant, only at 35 and 45 day stages, where C_2, C_3 and S_2, S_3, respectively, proved best and the values were at par with each other. However, all the interaction effects were non-significant.

4.2.8 Insoluble carbohydrate content in the root

The treatment proved ineffective in inducing any impact on this parameter (Table 7).

4.2.9 Nitrogen, phosphorus and potassium contents in the root

The roots of the plants raised from the treated seeds did not differ significantly in their nitrogen, phosphorus and potassium percentage, at all the stages of growth (Table 8).

4.2.10 Shoot length per plant

The seeds soaked in various hormones produced taller plants (Table 9). GA_3 (H_1) excelled by increasing plant height by 21.39%, over the control. It was followed by H_2 and H_3, in that order. The two higher concentrations (10^{-7} and 10^{-5} M) proved superior and their effect was at par with each other. As regards the soaking duration, 12(S_2) and 18(S_3) hours proved much better than 6(S_1) hours.

The two and three factor interactions were significant, at most of the stages of growth where H_1C_3, H_1C_4, H_1S_2, H_1S_3, C_3S_2, C_3S_3 and $H_1C_3S_3$, $H_1C_3S_2$ or $H_1C_4S_2$ proved best, at the three samplings.

Table 7. The per cent protein and soluble and insoluble carbohydrates in the root of the plants raised from the seeds pre-treated with water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M of GA_3 (H_1), IAA (H_2) or IBA (H_3) for 6 (S_1), 12 (S_2) or 18 (S_3) hours. The sampling was done at 25, 35 and 45 days, after sowing.

Treatments	**Protein**			**Sol. carbohydrate**			**Insol. carbohydrate**		
				DAYS AFTER SOWING					
	25	**35**	**45**	**25**	**35**	**45**	**25**	**35**	**45**
Control (C_1)	**17.00**	**16.05**	**15.22**	**3.10**	**4.15**	**4.25**	**37.90**	**31.95**	**24.01**
H_1	17.60	16.34	15.34	3.36	4.64	4.64	39.33	32.78	25.23
H_2	17.74	16.47	15.49	3.22	4.27	4.38	39.13	31.66	24.89
H_3	17.53	16.27	15.25	3.21	4.32	4.38	39.14	31.90	24.94
CD at 5%	**NS**	**NS**	**NS**	**0.113**	**0.077**	**0.073**	**NS**	**NS**	**NS**
C_2	17.41	16.17	15.13	3.29	4.50	4.57	39.46	32.43	25.31
C_3	17.58	16.32	15.31	3.30	4.49	4.55	39.44	32.65	25.33
C_4	17.88	16.59	15.63	3.18	4.24	4.29	38.70	31.27	24.42
CD at 5%	**NS**	**NS**	**NS**	**NS**	**0.077**	**0.073**	**NS**	**NS**	**NS**
S_1	17.51	16.26	15.23	3.20	4.28	4.29	37.79	31.74	24.61
S_2	17.87	16.59	15.62	3.30	4.47	4.54	39.88	32.55	25.20
S_3	17.49	16.24	15.22	3.28	4.49	4.58	39.92	32.06	25.25
CD at 5%	**NS**	**NS**	**NS**	**NS**	**0.077**	**0.073**	**NS**	**NS**	**NS**
H_1C_2	17.91	16.62	15.67	3.41	4.76	4.76	39.51	33.28	25.52
H_1C_3	17.42	16.18	15.14	3.40	4.76	4.74	39.49	33.31	25.51
H_1C_4	17.48	16.23	15.20	3.26	4.41	4.44	38.98	31.76	24.65
H_2C_2	17.13	15.92	14.83	3.25	4.34	4.48	39.43	31.67	25.18
H_2C_3	17.59	16.33	15.32	3.26	4.33	4.47	39.41	32.32	25.21
H_2C_4	18.52	17.16	16.31	3.15	4.15	4.20	38.56	31.00	24.27
H_3C_2	17.19	16.97	15.89	3.23	4.40	4.47	39.44	32.35	25.22
H_3C_3	17.75	16.47	15.49	3.25	4.38	4.45	39.41	32.33	25.28
H_3C_4	17.65	16.38	15.38	3.14	4.17	4.23	38.56	31.04	24.33
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
H_1S_1	17.71	16.43	15.45	3.26	4.37	4.36	37.83	32.15	24.79
H_1S_2	17.81	16.53	15.66	3.37	4.78	4.78	40.06	33.07	25.47
H_1S_3	17.29	16.06	15.00	3.45	4.78	4.80	40.09	33.13	25.43
H_2S_1	17.65	16.38	15.38	3.17	4.24	4.26	37.77	31.51	24.47
H_2S_2	17.90	16.61	15.65	3.27	4.26	4.42	39.78	31.94	25.05
H_2S_3	17.69	16.42	15.43	3.22	4.33	4.48	39.84	31.55	25.15
H_3S_1	17.17	15.95	14.87	3.19	4.23	4.25	37.77	31.58	24.57
H_3S_2	17.91	16.62	15.67	3.26	4.37	4.43	39.80	32.64	25.09
H_3S_3	17.50	16.25	15.22	3.18	4.35	4.48	39.84	31.50	25.17
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

C_2S_1	17.52	16.27	15.25	3.23	4.35	4.36	38.18	32.13	24.91
C_2S_2	17.56	16.31	15.29	3.24	4.58	4.64	40.09	32.79	25.47
C_2S_3	17.15	15.93	14.85	3.15	4.58	4.71	40.11	32.38	25.55
C_3S_1	17.23	16.01	14.94	3.32	4.33	4.33	38.15	32.10	24.95
C_3S_2	17.96	16.66	15.71	3.34	4.56	4.62	40.08	33.48	25.44
C_3S_3	17.56	16.31	15.29	3.23	4.58	4.71	40.08	32.38	25.60
C_4S_1	17.77	16.49	15.51	3.33	4.15	4.17	37.05	31.01	23.96
C_4S_2	18.10	16.79	15.87	3.33	4.28	4.36	39.47	31.37	24.70
C_4S_3	17.77	16.49	15.51	3.18	4.30	4.34	39.59	31.43	24.60
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_2S_1$	18.10	16.79	15.86	3.30	4.41	4.42	38.23	32.71	25.21
$H_1C_2S_2$	17.92	16.62	15.67	3.39	4.94	4.93	40.12	33.51	25.75
$H_1C_2S_3$	17.73	16.45	15.47	3.55	4.95	4.95	40.18	33.62	25.61
$H_1C_3S_1$	16.93	15.73	14.67	3.29	4.45	4.41	38.20	32.66	25.15
$H_1C_3S_2$	18.29	16.96	16.07	3.41	4.92	4.87	40.14	33.61	25.69
$H_1C_3S_3$	17.05	16.84	14.74	3.51	4.91	4.94	40.14	33.67	25.70
$H_1C_4S_1$	18.10	15.79	15.86	3.20	4.25	4.26	37.08	31.09	24.01
$H_1C_4S_2$	17.24	16.01	14.94	3.31	4.49	4.55	39.92	32.09	24.98
$H_1C_4S_3$	17.11	15.89	14.80	3.29	4.50	4.51	39.96	32.11	24.98
$H_2C_2S_1$	17.42	16.17	15.13	3.19	4.33	4.35	38.15	31.81	24.71
$H_2C_2S_2$	16.99	15.79	14.67	3.31	4.31	4.49	40.08	31.41	25.31
$H_2C_2S_3$	16.99	15.79	14.67	3.25	4.40	4.61	40.08	31.80	25.54
$H_2C_3S_1$	17.05	15.84	14.74	3.20	4.29	4.31	38.14	31.79	24.80
$H_2C_3S_2$	18.17	16.85	15.94	3.32	4.32	4.49	40.04	33.40	25.33
$H_2C_3S_3$	17.55	16.29	15.27	3.27	4.39	4.63	40.06	31.78	25.51
$H_2C_4S_1$	18.48	17.13	16.27	3.13	4.10	4.12	37.04	30.93	23.91
$H_2C_4S_2$	18.54	17.18	16.33	3.19	4.16	4.28	39.20	31.01	24.51
$H_2C_4S_3$	18.54	17.18	16.33	3.14	4.21	4.20	39.40	31.08	24.40
$H_3C_2S_1$	17.05	15.84	14.74	3.21	4.31	4.32	38.17	31.87	24.81
$H_3C_2S_2$	17.79	16.51	15.53	3.28	4.49	4.51	40.09	33.47	25.33
$H_3C_2S_3$	116.74	15.56	14.41	3.21	4.41	4.59	40.07	31.72	25.50
$H_3C_3S_1$	17.73	16.45	15.47	3.24	4.27	4.29	38.12	31.86	24.92
$H_3C_3S_2$	17.42	16.17	15.13	3.29	4.45	4.52	40.08	33.44	25.32
$H_3C_3S_3$	18.10	16.79	15.86	3.22	4.44	4.56	40.03	31.69	25.61
$H_3C_4S_1$	16.74	15.56	14.41	3.12	4.12	4.14	37.03	31.01	23.98
$H_3C_4S_2$	18.54	17.18	16.33	3.21	4.19	4.26	39.25	31.02	24.61
$H_3C_4S_3$	17.67	16.40	15.40	3.11	4.20	4.31	39.41	31.10	24.42
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 8. The per cent nitrogen, phosphorus and potassium in the root of the plants raised from the seeds pre-treated with water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M of GA_3 (H_1), IAA (H_2) or IBA (H_3) for 6 (S_1), 12 (S_2) or 18 (S_3) hours. The sampling was done at 25, 35 and 45 days, after sowing.

Treatments	Nitrogen			Phosphorus			Potassium		
	DAYS AFTER SOWING								
	25	35	45	25	35	45	25	35	45
Control(C_1)	**2.85**	**2.68**	**2.50**	**0.360**	**0.338**	**0.320**	**2.30**	**2.14**	**2.05**
H_1	2.96	2.76	2.60	0.370	0.347	0.329	2.39	2.24	2.12
H_2	2.98	2.78	2.63	0.372	0.349	0.332	2.40	2.26	2.14
H_3	2.94	2.75	2.59	0.368	0.346	0.328	2.38	2.23	2.12
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
C_2	2.95	2.73	2.57	0.366	0.344	0.325	2.36	2.22	2.10
C_3	2.93	2.76	2.60	0.369	0.347	0.329	2.38	2.24	2.12
C_4	2.00	2.80	2.65	0.375	0.351	0.334	2.42	2.27	2.16
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
S_1	2.94	2.75	2.59	0.368	0.345	0.327	2.38	2.23	2.11
S_2	3.00	2.80	2.65	0.374	0.351	0.334	2.42	2.27	2.16
S_3	2.94	2.74	2.58	0.368	0.345	0.327	2.37	2.23	2.11
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
H_1C_2	3.00	2.80	2.65	0.375	0.352	0.335	2.42	2.27	2.16
H_1C_3	2.93	2.73	2.57	0.366	0.344	0.326	2.37	2.22	2.10
H_1C_4	2.94	2.74	2.58	0.367	0.345	0.327	2.37	2.23	2.11
H_2C_2	2.88	2.69	2.52	0.361	0.339	0.320	2.38	2.19	2.07
H_2C_3	2.95	2.76	2.60	0.369	0.347	0.329	2.33	2.24	2.12
H_2C_4	3.10	2.89	2.75	0.386	0.362	0.346	2.49	2.34	2.24
H_3C_2	2.89	2.70	2.53	0.362	0.340	0.321	2.34	2.20	2.07
H_3C_3	2.89	2.78	2.63	0.372	0.349	0.332	2.40	2.26	2.14
H_3C_4	2.96	2.77	2.61	0.370	0.348	0.330	2.39	2.25	2.13
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
H_1S_1	2.97	2.77	2.62	0.371	0.349	0.331	2.40	2.25	2.14
H_1S_2	2.99	2.79	2.64	0.373	0.350	0.333	2.41	2.26	2.15
H_1S_3	2.91	2.72	2.65	0.364	0.342	0.323	2.35	2.21	2.09
H_2S_1	2.96	2.77	2.61	0.370	0.348	0.330	2.39	2.25	2.13
H2S2	3.00	2.80	2.65	0.375	0.352	0.335	2.42	2.27	2.16
H_2S_3	2.97	2.77	2.62	0.371	0.348	0.331	2.40	2.25	2.14
H_3S_1	2.89	2.70	2.53	0.362	0.340	0.321	2.34	2.20	2.07
H_3S_2	3.00	2.80	2.65	0.375	0.352	0.335	2.42	2.27	2.16
H_3S_3	2.94	2.75	2.58	0.365	0.345	0.327	2.37	2.23	2.11
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

C_2S_1	2.94	2.75	2.59	0.368	0.346	0.327	2.38	2.23	2.11
C_2S_2	2.95	2.75	2.60	0.369	0.346	0.328	2.38	2.24	2.12
C_2S_3	2.89	2.70	2.53	0.361	0.340	0.320	2.33	2.19	2.07
C_3S_1	2.90	2.71	2.54	0.363	0.341	0.322	2.34	2.20	2.08
C_3S_2	3.01	2.81	2.66	0.376	0.353	0.336	2.43	2.28	2.17
C_3S_3	2.95	2.75	2.60	0.369	0.346	0.328	2.38	2.24	2.12
C_4S_1	2.98	2.78	2.63	0.373	0.350	0.332	2.41	2.26	2.15
C_4S_2	3.03	2.83	2.69	0.378	0.355	0.339	2.44	2.29	2.19
C_4S_3	2.98	2.78	2.63	0.373	0.350	0.332	2.41	2.29	2.15
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_2S_1$	3.03	2.83	2.68	0.378	0.355	0.338	2.44	2.29	2.19
$H_1C_2S_2$	3.01	2.80	2.65	0.375	0.352	0.335	2.42	2.27	2.16
$H_1C_2S_3$	2.98	2.78	2.62	0.372	0.349	0.331	2.40	2.25	2.14
$H_1C_3S_1$	2.85	2.66	2.49	0.357	0.336	0.316	2.31	2.17	2.04
$H_1C_3S_2$	3.06	2.86	2.72	0.382	0.358	0.342	2.47	2.31	2.21
$H_1C_3S_3$	2.87	2.68	2.51	0.360	0.338	0.318	2.32	2.18	2.06
$H_1C_4S_1$	3.03	2.83	2.68	0.378	0.355	0.338	2.44	2.29	2.19
$H_1C_4S_2$	2.90	2.71	2.54	0.363	0.341	0.322	2.34	2.20	2.08
$H_1C_4S_3$	2.88	2.69	2.52	0.361	0.339	0.320	2.33	2.19	2.06
$H_2C_2S_1$	2.93	2.73	2.57	0.366	0.344	0.325	2.37	2.22	2.10
$H_2C_2S_2$	2.86	2.67	2.50	0.359	0.337	0.317	2.32	2.18	2.05
$H_2C_2S_3$	2.86	2.67	2.50	0.359	0.337	0.317	2.32	2.18	2.05
$H_2C_3S_1$	2.87	2.68	2.51	0.360	0.338	0.318	2.32	2.18	2.06
$H_2C_3S_2$	3.04	2.84	2.70	0.380	0.356	0.340	2.45	2.30	2.19
$H_2C_3S_3$	2.95	2.75	2.59	0.369	0.346	0.328	2.38	2.24	2.12
$H_2C_4S_1$	3.09	2.88	2.75	0.385	0.361	0.346	2.49	2.33	2.23
$H_2C_4S_2$	3.10	2.89	2.76	0.386	0.362	0.347	2.49	2.34	2.24
$H_2C_4S_3$	3.10	2.89	2.76	0.386	0.362	0.347	2.49	2.34	2.24
$H_3C_2S_1$	2.87	2.68	2.51	0.360	0.338	0.318	2.32	2.18	2.06
$H_3C_2S_2$	2.99	2.79	2.63	0.373	0.350	0.333	2.41	2.26	2.15
$H_3C_2S_3$	2.82	2.64	2.46	0.354	0.333	0.312	2.21	2.15	2.02
$H_3C_3S_1$	2.98	2.78	2.62	0.372	0.349	0.331	2.40	2.25	2.14
$H_3C_3S_2$	2.92	2.73	2.57	0.366	0.354	0.375	2.37	2.22	2.10
$H_3C_3S_3$	3.03	2.83	2.68	0.378	0.355	0.338	2.44	2.29	2.19
$H_3C_4S_1$	2.82	2.64	2.46	0.354	0.333	0.312	2.29	2.15	2.02
$H_3C_4S_2$	3.10	2.89	2.76	0.386	0.362	0.347	2.49	2.34	2.24
$H_3C_4S_3$	2.97	2.77	2.67	0.371	0.348	0.330	2.39	2.25	2.13
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

4.2.11 Shoot fresh weight per plant

It is evident form table 9 that shoot fresh weight was significantly enhanced by the treatment. A maximum progressive increase in fresh weight was recorded by GA_3 (H_1) and was followed by the auxins (H_2 and H_3) which produced a comparable response. At the early stage of growth (25 DAS), the highest concentration 10^{-5}M (C_4) was more effective but as the growth progressed (35 and 45 DAS), the medium concentration (C_3) proved best. Among the soaking durations, longer durations (S_2 and S_3) were more effective than the shorter (S_1) duration.

The interaction effect was significant only at two factors and that also largely at the early stages of growth. The maximum values were recorded with the combinations H_1C_4 and H_1S_3 at various samplings.

4.2.12 Shoot dry weight per plant

Shoot dry weight was significantly increased by the treatment and exhibited a pattern very much similar to that of the fresh weight where GA_3 (H_1) proved superior (Table 9). Here the higher concentrations (C_3 and C_4) of the hormones proved to be equally effective in enhancing the dry weight, throughout the growth period. Soaking the seeds for 12 (S_2) or 18 (S_3) hours proved best. However, the interaction of shoot dry weight with various factors of the treatment was non-significant.

4.2.13 Leaf number per plant

Table 10 reveals that the plants raised from the seeds treated with hormones had more leaves per plant than the control, at all the growth stages, studied. GA_3 (H_1) induced a maximum increase, followed by IBA(H_3)

Table 9. The length (cm), fresh and dry weight (g) of the shoot of the plants raised from the seeds pre-treated with water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M of GA_3 (H_1), IAA (H_2) or IBA (H_3) for 6 (S_1), 12 (S_2) or 18 (S_3) hours. The sampling was done at 25, 35 and 45 days, after sowing.

Treatments	Length			Fresh weight			Dry weight		
	DAYS AFTER SOWING								
	25	35	45	25	35	45	25	35	45
Control(C_1)	**7.90**	**19.00**	**24.00**	**0.545**	**0.805**	**1.156**	**0.165**	**0.250**	**0.400**
H_1	9.59	28.41	34.56	0.673	0 971	1.531	0.210	0.293	0.469
H_2	9.22	22.74	29.72	0.655	0.904	1.466	0.201	0.279	0.453
H_3	9.36	24.94	28.14	0.631	0.909	1.441	0.201	0.284	0.445
CD at 5%	**0.164**	**0.757**	**1.080**	**0.015**	**0.015**	**0.042**	**0.005**	**0.009**	**0.007**
C_2	8.83	23.82	29.26	0.616	0.898	1.435	0.192	0.278	0.444
C_3	9.74	27.42	31.45	0.654	0.948	1.516	0.209	0.292	0.462
C_4	9.61	24.85	31.71	0.689	0.938	1.487	0.212	0.287	0.462
CD at 5%	**0.164**	**0.757**	**1.080**	0.015	**0.015**	**0.042**	**0.005**	**0.009**	**0.007**
S_1	8.01	20.84	27.12	0.550	0.832	1.361	0.172	0.257	0.417
S_2	9.98	28.02	32.90	0.693	0.972	1.570	0.216	0.296	0.475
S_3	10.19	27.23	32.41	0.716	0.980	1.507	0.225	0.303	0.476
CD at 5%	**0.164**	**0.757**	**1.080**	0.015	**0.015**	**0.042**	**0.005**	**0.009**	**0.007**
H_1C_2	9.80	27.73	30.90	0.614	0.920	1.454	0.197	0.281	0.547
H_1C_3	9.94	29.63	35.70	0.688	1.001	1.590	0.214	0.303	0.476
H_1C_4	9.84	27.86	37.10	0.717	0.991	1.549	0.221	0.295	0.474
H_2C_2	8.80	21.73	27.76	0.638	0.876	1.455	0.191	0.273	0.444
H_2C_3	9.89	24.40	31.03	0.653	0.935	1.501	0.204	0.287	0.458
H_2C_4	9.48	22.10	30.36	0.674	0.901	1.441	0.209	0.278	0.457
H_3C_2	8.69	22.00	29.13	0.595	0.898	1.397	0.187	0.278	0.430
H_3C_3	9.90	28.23	27.63	0.620	0.909	1.457	0.209	0.286	0.451
H_3C_4	9.50	24.60	27.16	0.678	0.921	1.470	0.208	0.287	0.455
CD at 5%	**NS**	**1.311**	**1.870**	0.026	0.026	**NS**	**NS**	**NS**	**NS**
H_1S_1	7.93	22.86	30.20	0.551	0.838	1.386	0.173	0.256	0.425
H_1S_2	10.24	31.56	37.23	0.730	1.053	1.592	0.227	0.308	0.492
H_1S_3	10.61	30.80	36.26	0.737	1.021	1.615	0.231	0.316	0.490
H_2S_1	8.02	19.03	24.06	0.550	0.830	1.348	0.172	0.258	0.416
H_2S_2	9.86	23.56	33.46	0.689	0.926	1.569	0.214	0.289	0.471
H_2S_3	9.80	25.63	31.63	0.727	0..956	1.480	0.218	0.292	0472
H_3S_1	8.09	20.63	27.10	0..550	0.827	1.350	0.171	0.257	0.409
H_3S_2	9.83	28.93	28.00	0..660	0.938	1.550	0.208	0.293	0.461
H_3S_3	10.17	25.26	29.33	0..683	0.963	1.425	0.225	0.301	0.467
CD at 5%	**0.285**	**1.311**	**1.870**	**0..026**	**0.026**	**0.073**	**NS**	**NS**	**NS**

C_2S_1	7.98	20.40	25.73	0.514	0.818	1.293	0.166	0.255	0.406
$C2S_2$	9.13	24.93	30..66	0.636	0.938	1.571	0.198	0.285	0.462
C_2S_3	9.39	26.13	31.40	0.698	0.938	1.442	0.211	0.293	0.463
C_3S_1	7.96	21.80	28.10	0.539	0853	1.392	0.170	0..261	0.477
C_3S_2	10.45	31.30	34.16	0.723	0.997	1.589	0.226	0.303	0.480
C_3S_3	10.82	29.16	32.10	0.700	0.995	1.568	0.230	0.312	0.483
C_4S_1	8.10	20.33	27.53	0.599	0.824	1.399	0.180	0.256	0.421
C_4S_2	10.34	27.83	33.86	0.720	0.983	1.551	0.225	0.301	0.482
C_4S_3	10.38	26.40	33.73	0.749	1.007	1.510	0.233	0.304	0.482
CD at 5%	**0.285**	**1.311**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_2S_1$	7.52	22.90	27.50	0.527	0.779	1.320	0.178	0.246	0.417
$H_1C_2S_2$	9.67	29.70	31.80	0.663	1.020	1.530	0.203	0.296	0.479
$H_1C_2S_3$	9.83	30.60	33.40	0.653	0.961	1.513	0.210	0.305	0.476
$H1C_3S_1$	7.85	24.30	30.60	0.514	0.903	1.437	0.160	0.268	0.431
$H_1C_3S_2$	10.73	32.10	39.60	0.782	1.110	1.622	0.243	0.318	0.496
$H_1C_3S_3$	11.25	32.50	36.90	0.767	0.989	1.712	0.238	0.324	0.502
$H_1C_4S_1$	8.43	21.40	32.50	0.613	0.831	1.401	0.182	0.258	0.428
$H_1C_4S_2$	10.34	32.90	40.30	0.745	1.030	1.624	0.236	0.309	0.500
$H_1C_4S_3$	10.76	29.30	38.50	0.792	1.112	1.621	0.244	0.318	0.493
$H_2C_2S_1$	8.34	18.80	23.80	0.505	0.824	1.270	0.163	0.259	0.410
$H_2C_2S_2$	8.79	21.20	30.90	0.642	0.894	1.602	0.200	0.278	0.459
$H_2C_2S_3$	9.28	25.20	28.60	0.768	0.911	1.492	0.211	0.283	0.463
$H_2C_3S_1$	7.79	19.60	24.50	0.549	0.843	1.363	0.171	0.265	0.421
$H_2C_3S_2$	10.28	26.50	35.40	0.707	0.941	1.610	0.221	0.293	0.475
$H_2C_3S_3$	10.12	27.10	33.20	0.704	1.021	1.531	0.220	0.302	0.478
$H_2C_4S_1$	7.94	18.70	23.90	0.595	0.824	1.412	0.183	0.249	0.416
$H_2C_4S_2$	10.51	23.00	34.10	0.718	0.944	1.494	0.220	0.295	0.480
$H_2C_4S_3$	10.01	24.60	33.10	0.708	0.936	1.416	0.224	0.291	0.474
$H_3C_2S_1$	8.08	19.50	25.90	0.509	0.852	1.290	0.157	0.263	0.391
$H_3C_2S_2$	8.95	23.90	29.30	0.604	0.900	1.580	0.192	0.281	0.448
$H_3C_2S_3$	9.06	22.60	32.20	0.673	0.941	1.321	0.213	0.291	0.451
$H_3C_3S_1$	8.26	21.50	29.20	0.553	0.814	1.375	0.180	0.249	0.415
$H_3C_3S_2$	10.34	35.30	27.50	0.679	0.939	1.535	0.215	0.298	0.469
$H_3C_3S_3$	11.09	27.90	26.20	0.629	0.975	1.461	0.231	0.311	0.470
$H_3C_4S_1$	7.93	20.90	26.20	0.588	0.816	1.384	0.175	0.260	0.420
$H_3C_4S_2$	10.19	2760	27.20	0.598	0.974	1.534	0.218	0.300	0.465
$H_3C_4S_3$	10.38	25.30	29.60	0.748	0.973	1.493	0.230	0.302	0.480
CD at 5%	**0.494**	**2.272**	**3.240**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

and IAA(H_2). The leaf number exhibited a linear increase with an increase in the concentration of the hormones (10^{-9} to 10^{-5} M). An extended soaking treatment of the seeds (S_2 or S_3) increased the leaf number to a maximum value but the data was comparable with each other. The interaction effect of various factors and the parameter was non-significant.

4.2.14 Leaf nitrate reductase activity (NRA)

The NRA was significantly enhanced by the treatment. Its values increased upto 35 DAS but decreased, thereafter (Table 10). The superiority of GA_3 (H_1) was again prominent and was followed by IAA (H_2) and IBA (H_3). As regards the hormone concentrations, the two higher concentrations (C_3 and C_4) exhibited a comparable effect, at the two early stages of growth but C_4 excelled, at the later stage of growth (45 DAS). The effect of soaking duration was very significant and the values, at all the three stages of growth, increased with an increase in the soaking intervals.

The two and three factor interactions were significant. The values were maximum with H_1C_3, H_1S_2, C_3S_3 and $H_1C_3S_3$ (i.e., the seeds soaked in 10^{-7}M of GA_3 for 18 hours).

4.2.15 Nitrate content in the shoot

The nitrate content decreased as the growth progressed and was significantly affected by the treatment (Table 10). The maximum values were recorded in the plants raised from the seeds pre-treated with IAA(H_2), followed by GA_3 (H_1) and IBA (H_3). The nitrate level showed a linear increase with an increase in the level of the hormones and the duration of soaking of the seeds, at all the stages of growth. Two factor interactions

Table 10. The leaf number, level of nitrate reductase (NRA; m moles $g^{-1}h^{-1}fw$) in the leaves and nitrate ($\mu g \times 10^{-3} g^{-1}$) in the shoot of the plants raised from the seeds pre-treated with water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M of GA_3 (H_1), IAA (H_2) or IBA (H_3) for 6 (S_1), 12 (S_2) or 18 (S_3) hours. The sampling was done at 25, 35 and 45 days, after sowing.

Treatments	Leaf number			NRA			Nitrate		
	DAYS AFTER SOWING								
	25	35	45	25	35	45	25	35	45
Control(C_1)	**3.20**	**5.05**	**6.35**	**0.655**	**0.570**	**0.550**	**167**	**120**	**101**
H_1	3.95	5.59	7.44	0.731	0.659	0.714	171	128	110
H_2	3.35	5.24	6.82	0.696	0.625	0.610	175	130	113
H_3	3.51	5.35	7.00	0.681	0.610	0.603	170	126	108
CD at 5%	**0.12**	**0.08**	**0.10**	**0.008**	**0.009**	**0.011**	**3**	**2**	**2**
C_2	3.51	5.27	6.96	0.672	0.602	0.623	172	128	110
C_3	3.54	5.36	7.05	0.720	0.649	0.665	176	131	114
C_4	3.76	5.54	7.25	0.714	0.643	0.639	177	133	117
CD at 5%	**0.12**	**0.08**	**0.10**	0.008	**0.009**	**0.011**	**3**	**3**	**3**
S_1	3.31	5.21	6.43	0.639	0.570	0.600	171	127	109
S_2	3.81	5.34	7.43	0.728	0.656	0.655	171	127	109
S_3	3.69	5.61	7.41	0.740	0.667	0.673	174	130	112
CD at 5%	**0.12**	**0.08**	**0.10**	0.008	**0.009**	**0.011**	**3**	**2**	**2**
H_1C_2	3.84	5.50	7.30	0.702	0.631	0.696	171	127	109
H_1C_3	3.89	5.55	7.47	0.760	0.687	0.756	176	131	114
H_1C_4	4.13	5.71	7.55	0.729	0.657	0.691	176	132	114
H_2C_2	3.29	5.07	6.70	0.673	0.603	0.596	176	132	115
H_2C_3	3.29	5.22	6.73	0.709	0.638	0.628	178	133	116
H_2C_4	3.47	5.43	7.03	0.705	0.634	0.605	181	136	120
H_3C_2	3.40	5.23	6.87	0.642	0.574	0.577	168	124	105
H_3C_3	3.46	5.31	6.97	0.692	0.621	0.611	174	130	112
H_3C_4	3.48	5.50	7.17	0.708	0.637	0.622	175	131	113
CD at 5%	**NS**	**NS**	**NS**	**0.015**	**0.015**	**0.019**	**5**	**4**	**4**
H_1S_1	3.49	5.45	6.85	0.657	0.588	0.624	171	127	109
H_1S_2	4.17	5.53	7.69	0.771	0.698	0.724	171	127	109
H_1S_3	4.70	5.78	7.78	0.763	0.690	0.795	173	129	111
H_2S_1	3.27	5.05	6.10	0.635	0.566	0.582	174	130	112
H_2S_2	3.54	5.17	7.20	0.714	0.642	0.631	174	130	112
H_2S_3	3.23	5.50	7.16	0.739	0.666	0.616	176	132	115
H_3S_1	3.18	5.31	6.34	0.625	0.557	0.593	169	125	107
H_3S_2	3.73	5.33	7.39	0.699	0.628	0.609	169	126	107
H_3S_3	3.63	5.37	7.28	0.717	0.646	0609	172	128	110
CD at 5%	**NS**	**NS**	**NS**	**0.015**	**0.015**	**0.019**	**NS**	**NS**	**NS**

C_2S_1	3.18	5.16	6.32	0.633	0.564	0.581	171	127	109
C_2S_2	3.77	5.22	7.29	0.687	0.616	0.618	173	129	111
C_2S_3	3.58	5.42	7.26	0.698	0.627	0.671	171	127	109
C_3S_1	3.23	5.17	6.39	0.642	0.573	0.611	174	130	112
C_3S_2	3.73	5.35	7.38	0.751	0.678	0.607	173	129	111
C_3S_3	3.68	5.57	7.40	0.769	0.696	0.718	180	135	118
C_4S_1	3.54	5.31	6.58	0.643	0.574	0.690	176	132	114
C_4S_2	3.94	5.47	7.61	0.747	0.675	0.656	175	131	113
C_4S_3	3.80	5.85	7.57	0.752	0.680	0.694	181	137	120
CD at 5%	**NS**	**NS**	**NS**	**0.015**	**0.015**	**0.019**	**5**	**4**	**4**
$H_1C_2S_1$	3.34	5.36	6.78	0.649	0.579	0.604	170	126	108
$H_1C_2S_2$	4.15	5.43	7.52	0.739	0.667	0.693	172	128	11
$H_1C_2S_3$	4.03	5.73	7.61	0.719	0.647	0.791	170	127	108
$H_1C_3S_1$	3.42	5.43	6.84	0.660	0.590	0.639	175	131	113
$H_1C_3S_2$	4.05	5.56	7.74	0.799	0.725	0.782	175	130	113
$H_1C_3S_3$	4.21	5.68	7.83	0.822	0.748	0.846	178	133	116
$H_1C_4S_1$	3.72	5.75	6.95	0.664	0.594	0.628	174	130	112
$H_1C_4S_2$	4.33	5.62	7.81	0.776	0.703	0.698	174	130	112
$H_1C_4S_3$	4.36	5.94	7.91	0.748	0.676	0.748	180	136	119
$H_2C_2S_1$	3.16	4.96	5.94	0.630	0.561	0.566	175	131	113
$H_2C_2S_2$	3.56	5.03	7.14	0.667	0.597	0.590	178	134	117
$H_2C_2S_3$	3.16	5.24	7.02	0.723	0.651	0.633	175	131	114
$H_2C_3S_1$	3.21	5.05	6.02	0.635	0.566	0.602	176	132	115
$H_2C_3S_2$	3.43	5.14	7.05	0.749	0.677	0.671	173	129	111
$H_2C_3S_3$	3.24	5.48	7.14	0.744	0.671	0.611	183	138	122
$H_2C_4S_1$	3.46	5.14	6.34	0.640	0.571	0.578	180	136	119
$H_2C_4S_2$	3.64	5.36	7.43	0.726	0.654	0.632	180	135	118
$H_2C_4S_3$	3.31	5.79	7.34	0.749	0.677	0.604	184	139	122
$H_3C_2S_1$	3.04	5.18	6.26	0.619	0.550	0.574	167	124	105
$H_3C_2S_2$	3.62	5.21	7.21	0.655	0.586	0.560	170	126	107
$H_3C_2S_3$	3.56	5.31	7.16	0.651	0.582	0.589	166	123	104
$H_3C_3S_1$	3.07	5.03	6.31	0.632	0.563	0.590	171	127	109
$H_3C_3S_2$	3.71	5.35	7.36	0.704	0.633	0.618	172	128	110
$H_3C_3S_3$	3.60	5.56	7.24	0.740	0.668	0.626	178	134	116
$H_3C_4S_1$	3.45	5.24	6.45	0.625	0.556	0.615	174	129	112
$H_3C_4S_2$	3.87	5.44	7.61	0.739	0.667	0.639	171	127	109
$H_3C_4S_3$	3.74	5.84	7.46	0.760	0.687	0.610	180	136	119
CD at 5%	**NS**	**NS**	**NS**	**0.026**	**0.023**	**0.033**	**NS**	**NS**	**NS**

were significant where H_2C_4 and C_4S_3 proved to be the best combinations.

4.2.16 Protein content in the shoot

It is evident from table 11 that the treatment has no impact on the protein percentage of the shoot. All the interaction effects were also non-significant.

4.2.17 Soluble carbohydrate content in the shoot

The soluble carbohydrate content increased with the growth of the plants. Its level was significantly enhanced by the treatment (Table 11). A maximum increase was recorded by GA_3 (H_1), at all the samplings. The effectivity of the hormone concentration depended on the stage of growth. The soluble carbohydrate content in the shoot, at the three stages of growth, increased with the duration of soaking. H_1S_3 is the only combination interacted significantly with the parameter, at 25 and 35 DAS.

4.2.18 Insoluble carbohydrate content in the shoot

The insoluble carbohydrate content decreased with an increase in the age of the plants but was not influenced by the treatment (Table 11). The interaction effect was also non-significant.

4.2.19 Nitrogen, phosphorus and potassium contents in the shoot

All these elements exhibited a decreasing trend with the advancement of the age of the plants but remained unaffected by the treatment (Table 12).

Table 11. The per cent protein and soluble and insoluble carbohydrates in the shoot of the plants raised from the seeds pre-treated with water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M of GA_3 (H_1), IAA (H_2) or IBA (H_3) for 6 (S_1), 12 (S_2) or 18 (S_3) hours. The sampling was done at 25, 35 and 45 days, after sowing.

Treatments	Protein			Sol. carbohydrate			Insol. Carbohydrate		
	DAYS AFTER SOWING								
	25	35	45	25	35	45	25	35	45
Control(C_1)	**16.35**	**15.55**	**14.00**	**4.20**	**5.00**	**5.30**	**36.90**	**29.99**	**23.55**
H_1	17.16	15.78	14.67	4.93	5.85	6.48	38.31	31.78	24.20
H_2	17.32	16.92	14.83	4.44	5.67	5.85	38.12	30.88	23.87
H_3	17.08	16.70	14.58	4.42	5.66	5.93	38.13	30.92	23.94
CD at 5%	**NS**	**NS**	**NS**	**0.07**	**0.10**	**0.12**	**NS**	**NS**	**NS**
C_2	16.95	15.49	14.44	4.68	5.80	6.04	38.45	31.67	24.30
C_3	17.14	15.76	14.65	4.66	5.79	6.06	38.42	31.65	24.32
C_4	17.47	16.05	15.00	4.46	5.60	6.16	37.70	30.25	23.40
CD at 5%	**NS**	**NS**	**NS.**	**NS**	**0.10**	**NS**	**NS**	**NS**	**NS**
S_1	17.06	15.68	14.56	4.28	5.08	5.46	38.77	30.74	23.62
S_2	17.46	16.04	14.99	4.69	5.89	6.27	38.87	31.77	24.16
S_3	17.04	15.67	14.54	4.63	6.22	6.52	38.92	31.06	24.25
CD at 5%	**NS**	**NS**	**NS**	**0.07**	**0.10**	**0.12**	**NS**	**NS**	**NS**
H_1C_2	17.50	16.08	15.03	5.00	5.95	6.49	38.50	32.30	24.49
H_1C_3	16.96	15.59	14.45	5.00	5.92	6.50	38.47	32.30	24.50
H_1C_4	17.03	15.65	14.52	4.81	5.69	6.45	37.97	30.74	23.63
H_2C_2	16.64	15.31	14.11	4.53	5.73	5.78	38.42	31.34	24.19
H_2C_3	17.14	15.76	14.65	4.49	5.72	5.79	38.39	31.32	24.21
H_2C_4	18.17	16.68	15.74	4.31	5.57	5.97	37.55	29.99	23.23
H_3C_2	16.71	15.37	14.18	4.50	5.72	5.84	38.43	31.39	24.23
H_3C_3	17.32	15.92	14.84	4.49	5.73	5.88	38.40	31.33	24.27
H_3C_4	17.21	15.82	14.72	4.28	5.55	6.06	37.57	30.03	23.33
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
H_1S_1	17.28	15.88	14.79	4.35	5.11	5.79	36.81	31.15	23.78
H_1S_2	17.39	15.98	14.92	5.19	5.98	6.82	39.05	32.08	24.42
H_1S_3	16.82	15.47	14.30	5.26	6.46	6.82	39.09	32.11	24.42
H_2S_1	17.21	15.82	14.72	4.26	5.05	5.29	36.74	30.50	23.48
H_2S_2	17.49	16.07	15.01	4.44	5.88	5.91	38.77	31.60	23.99
H_2S_3	17.26	15.86	14.77	4.63	6.09	6.34	38.85	30.55	24.16
H_3S_1	16.69	15.35	14.16	4.25	5.08	5.30	36.75	30.58	23.59
H_3S_2	17.50	16.08	15.03	4.43	5.82	6.09	38.81	31.65	24.07
H_3S_3	17.05	15.67	14.55	4.60	6.10	6.39	38.83	30.53	24.17
CD at 5%	**NS**	**NS**	**NS**	**0.167**	**0.199**	**NS**	**NS**	**NS**	**NS**

C_2S_1	17.07	15.69	14.57	4.36	5.16	5.35	37.14	31.13	23.94
C_2S_2	17.12	15.74	14.62	4.75	5.90	6.27	37.13	32.49	2442
C_2S_3	16.66	1533	14.03	4.93	6.34	6.50	36.04	31.40	24.55
C_3S_1	16.76	15.41	14.23	4.36	5.15	5.38	39.09	31.11	23.95
C_3S_2	17.55	16.13	15.08	4.75	5.92	6.27	39.05	32.47	24.42
C_3S_3	17.12	15.74	14.62	4.87	6.29	6.52	38.48	31.38	24.60
C_4S_1	17.35	15.94	14.86	4.14	4.93	5.65	39.11	29.99	22.96
C_4S_2	17.71	16.27	15.26	4.57	5.85	6.29	39.08	30.36	23.64
C_4S_3	17.35	15.94	14.86	4.69	6.03	6.53	38.58	30.41	23.59
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_2S_1$	17.71	16.26	15.25	4.41	5.20	5.69	37.19	31.78	24.20
$H_1C_2S_2$	17.51	16.09	15.04	5.21	6.04	5.89	39.13	32.58	24.59
$H_1C_2S_3$	17.30	15.90	14.81	5.40	6.61	6.90	39.19	32.61	24.60
$H_1C_3S_1$	16.42	15.11	13.87	4.45	5.15	5.71	37.17	31.67	24.14
$H_1C_3S_2$	17.91	16.45	15.47	5.25	6.02	6.91	39.11	32.59	24.67
$H_1C_3S_3$	16.55	15.23	14.01	5.30	6.59	6.88	39.15	32.65	24.69
$H_1C_4S_1$	17.71	16.26	15.25	4.20	4.99	5.98	36.07	30.07	23.01
$H_1C_4S_2$	16.76	15.41	14.24	5.13	5.89	6.68	38.91	31.07	23.91
$H_1C_4S_3$	16.62	15.28	14.08	5.10	6.20	6.69	38.95	31.09	23.97
$H_2C_2S_1$	16.96	15.59	14.45	4.35	5.13	5.17	37.11	30.81	23.74
$H_2C_2S_2$	16.48	15.17	13.94	4.55	5.88	5.87	39.07	32.41	23.28
$H_2C_2S_3$	16.48	15.17	13.94	4.71	6.20	6.31	39.09	30.80	24.55
$H_2C_3S_1$	16.55	15.23	14.01	4.31	5.14	5.20	37.10	30.80	23.81
$H_2C_3S_2$	17.78	16.33	15.33	4.47	5.87	5.89	39.02	32.39	24.29
$H_2C_3S_3$	17.10	15.72	14.60	4.69	6.15	6.30	39.06	30.79	24.54
$H_2C_4S_1$	18.12	16.64	15.70	4.12	4.90	5.51	36.03	29.91	22.90
$H_2C_4S_2$	18.19	16.70	15.77	4.31	5.91	5.99	38.22	30.00	23.41
$H_2C_4S_3$	18.19	16.70	15.77	4.50	5.92	6.41	38.41	30.07	23.39
$H_3C_2S_1$	16.55	15.23	14.01	4.34	5.16	5.19	37.13	30.89	23.89
$H_3C_2S_2$	17.36	15.96	14.88	4.49	5.80	6.05	39.09	32.49	24.30
$H_3C_2S_3$	16.21	14.92	13.65	4.68	6.21	6.29	39.07	30.79	24.51
$H_3C_3S_1$	17.30	15.90	14.81	4.32	5.17	5.24	37.12	30.87	23.91
$H_3C_3S_2$	16.96	15.59	14.45	4.53	5.89	6.02	39.04	32.45	24.31
$H_3C_3S_3$	17.71	16.26	15.25	4.63	6.13	6.39	39.04	30.71	24.59
$H_3C_4S_1$	16.21	14.92	13.65	4.10	4.91	5.48	36.02	30.00	22.99
$H_3C_4S_2$	18.19	16.70	15.77	4.27	5.77	6.21	38.32	30.01	23.61
$H_3C_4S_3$	17.23	15.84	17.74	4.49	5.98	6.51	38.39	30.09	23.41
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 12. The per cent nitrogen, phosphorus and potassium in the shoot of the plants raised from the seeds pre-treated with water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M of GA_3 (H_1), IAA (H_2) or IBA (H_3) for 6 (S_1), 12 (S_2) or 18 (S_3) hours. The sampling was done at 25, 35 and 45 days, after sowing.

Treatments	Nitrogen			Phosphorus			Potassium		
	DAYS AFTER SOWING								
	25	35	45	25	35	45	25	35	45
Control(C_1)	**2.79**	**2.60**	**2.40**	**0.350**	**0.328**	**0.305**	**2.24**	**1.95**	**1.70**
H_1	2.89	2.67	2.50	0.362	0.337	0.317	2.34	2.05	1.74
H_2	2.91	2.69	2.52	0.364	0.339	0.320	2.35	2.07	1.92
H_3	2.87	2.66	2.48	0.360	0.336	0.316	2.33	2.04	1.90
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
C_2	2.85	2.64	2.56	0.358	0.343	0.313	2.31	2.09	1.87
C_3	2.88	2.67	2.46	0.361	0.337	0.317	2.33	2.02	1.84
C_4	2.94	2.71	2.48	0.367	0.342	0.323	2.37	2.03	1.97
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
S_1	2.87	2.66	2.48	0.360	0.335	0.315	2.32	2.03	2.16
S_2	2.93	2.71	2.55	0.367	0.342	0.323	2.37	2.08	2.21
S_3	2.87	2.65	2.48	0.360	0.335	0.315	2.32	2.03	2.01
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
H_1C_2	2.94	2.72	2.56	0.368	0.342	0.324	2.38	2.09	1.76
H_1C_3	2.86	2.64	2.46	0.358	0.334	0.313	2.31	2.02	1.72
H_1C_4	2.87	2.65	2.48	0.359	0.335	0.315	2.32	2.03	1.74
H_2C_2	2.81	2.60	2.41	0.352	0.329	0.307	2.28	1.98	2.12
H_2C_3	2.89	2.67	2.50	0.361	0.337	0.317	2.33	2.05	1.76
H_2C_4	3.04	2.81	2.67	0.380	0.353	0.336	2.45	2.17	1.81
H_3C_2	2.82	2.61	2.42	0.354	0.330	0.308	2.28	1.99	1.72
H_3C_3	2.91	2.69	2.52	0.365	0.339	0.320	2.35	2.07	1.75
H_3C_4	2.90	2.68	2.51	0.363	0.338	0.318	2.34	2.05	1.75
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
H_1S_1	2.91	2.69	2.52	0.364	0.339	0.319	2.35	2.06	2.19
H_1S_2	2.92	2.70	2.54	0.366	0.341	0.322	2.36	2.08	2.2
H_1S_3	2.83	2.62	2.44	0.356	0.331	0.311	2.30	2.01	1.84
H_2S_1	2.90	2.68	2.51	0.363	0.338	0.318	2.34	2.05	2.18
H_2S_2	2.94	2.72	2.55	0.367	0.342	0.323	2.37	2.09	2.21
H_2S_3	2.90	2.68	2.51	0.363	0.338	0.319	2.35	2.06	2.03
H_3S_1	2.81	2.60	2.42	0.353	0.329	0.308	2.28	2.13	1.99
H_3S_2	2.94	2.72	2.56	0.368	0.342	0.324	2.38	2.21	2.09
H_3S_3	2.87	2.66	2.48	0.360	0.335	0.315	2.32	1.88	2.03
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

C_2S_1	2.87	2.66	2.48	0.360	0.335	0.315	2.33	2.17	2.04
C_2S_2	2.88	2.67	2.49	0.361	0.336	0.316	2.33	2.17	2.04
C_2S_3	2.81	2.60	2.41	0.353	0.329	0.308	2.28	1.97	1.99
C_3S_1	2.82	2.61	2.43	0.354	0.330	0.309	2.29	2.13	2.00
C_3S_2	2.95	2.73	2.56	0.369	0.343	0.325	2.38	2.22	2.10
C_3S_3	2.88	2.67	2.49	0.359	0.336	0.316	2.33	2.07	2.04
C_4S_1	2.92	2.70	2.53	0.365	0.340	0.321	2.36	2.19	2.07
C_4S_2	2.97	2.75	2.59	0.372	0.346	0.328	2.40	2.23	2.12
C_4S_3	2.92	2.70	2.53	0.365	0.340	0.321	2.36	1.98	2.07
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_2S_1$	2.97	2.75	2.59	0.371	0.346	0.327	2.40	2.23	2.11
$H_1C_2S_2$	2.94	2.72	2.56	0.368	0.342	0.324	2.38	2.21	2.09
$H_1C_2S_3$	2.91	2.69	2.52	0.364	0.339	0.320	2.35	2.15	2.06
$H_1C_3S_1$	2.77	2.57	2.37	0.348	0.325	0.303	2.25	2.10	1.96
$H_1C_3S_2$	2.01	2.78	2.62	0.375	0.349	0.331	2.42	2.25	2.14
$H_1C_3S_3$	2.79	2.59	2.40	0.351	0.327	0.305	2.27	2.06	1.97
$H_1C_4S_1$	2.97	2.75	2.59	0.371	0.346	0.327	2.40	2.23	2.11
$H_1C_4S_2$	2.82	2.61	2.43	0.354	0.330	0.309	2.29	2.13	2.00
$H_1C_4S_3$	2.80	2.59	2.41	0.352	0.328	0.307	2.27	1.96	1.98
$H_2C_2S_1$	2.86	2.64	2.46	0.358	0.334	0.313	2.31	2.15	2.02
$H_2C_2S_2$	2.78	2.58	2.38	0.350	0.326	0.304	2.26	2.10	1.96
$H_2C_2S_3$	2.78	2.58	2.38	0.350	0.326	0.304	2.26	2.10	1.96
$H_2C_3S_1$	2.79	2.59	2.40	0.351	0.327	0.305	2.27	2.11	1.97
$H_2C_3S_2$	2.98	2.76	2.60	0.373	0.347	0.329	2.41	2.24	2.12
$H_2C_3S_3$	2.88	2.66	2.49	0.361	0.336	0.316	2.33	1.92	2.04
$H_2C_4S_1$	3.04	2.81	2.66	0.379	0.352	0.335	2.45	2.28	2.17
$H_2C_4S_2$	3.05	2.82	2.67	0.380	0.353	0.337	2.45	2.28	2.19
$H_2C_4S_3$	3.05	2.82	2.67	0.380	0.353	0.337	2.45	1.98	2.17
$H_3C_2S_1$	2.79	2.59	2.40	0.351	0.327	0.305	2.27	2.11	1.97
$H_3C_2S_2$	2.92	2.70	2.53	0.365	0.340	0.321	2.36	2.20	2.07
$H_3C_2S_3$	2.74	2.54	2.34	0.345	0.322	0.299	2.23	2.15	1.93
$H_3C_3S_1$	2.91	2.69	2.52	0.364	0.339	0.320	2.35	2.19	2.06
$H_3C_3S_2$	2.86	2.64	2.46	0.358	0.334	0.313	2.31	2.15	2.02
$H_3C_3S_3$	2.97	2.75	2.59	0.371	0.346	0.327	2.40	2.09	2.11
$H_3C_4S_1$	2.74	2.54	2.34	0.345	0.322	0.299	2.43	2.08	1.93
$H_3C_4S_2$	3.05	2.82	2.67	0.380	0.353	0.337	2.45	2.28	2.17
$H_3C_4S_3$	2.90	2.68	2.51	0.363	0.338	0.318	2.34	2.20	2.06
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

4.3 Experiment 3

This sand culture, pot experiment was conducted to study the effect of three levels, 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M, each of GA_3 (H_1), IAA (H_2) or IBA (H_3), applied along with the full nutrient solution. The control (C_1) plants were supplied with the nutrient solution only. The hormones were fed once 7 (R_1), 14 (R_2) or twice 7 and 14 (R_3) days, after the emergence of the seedlings. The samples were collected and assessed in the same way as in Experiment 2. The values for various parameters are presented in tables 13 to 20 and described, in short, in the following pages:

4.3.1 Root length per plant

The plants raised from the seeds pre-treated with hormones possessed longer roots than the control (Table 13). Comparable and significantly higher values were recorded by the auxins (H_2 and H_3) than GA_3 (H_1). Root length increased with an increase in the hormone concentration but at the last two stages (35 and 45 DAS) C_3 and C_4 induced a comparable response. The application of hormones two times (R_3) was far superior than once (R_1 or R_2), at all the stages of growth. The interaction effect was totally non-significant.

4.3.2 Root fresh weight per plant

The treatment significantly improved the root fresh weight, at 25 and 45 DAS (Table 13). The values increased with the age of the plant and gave maximum response to GA_3 (H_1) but was statistically equal to that of IAA (H_2), at the early stage of growth (25 DAS). An increase in the hormone concentration induced a linear increase in the root fresh weight.

Moreover, the effect of the two higher concentrations (10^{-7} and 10^{-5}M) was statistically equal, at all the stages of growth. The hormonal application twice (R_3) was superior than single applications (R_1 or R_2) whose effect was comparable with each other. The interaction effect was non-significant.

4.3.3 Root dry weight per plant

The root dry weight did not show any significant response to the treatment and the interaction effect was also non-significant (Table 13).

4.3.4 Nitrate reductase activity in the root

The effect of the treatment on NRA, at all the growth stages, was significant (Table 14). The treatments differed significantly, with each other, in their effect. Highest values were recorded with GA_3 (H_1) which was followed by those of IAA (H_2) and IBA (H_3), in that order. The two higher concentrations (C_3 and C_4) were at par in their effect in inducing maximum activity of NR. Feeding the hormone once, irrespective of their application time (R_1 or R_2) induced a similar response but was excelled by its application twice (R_3). The interaction effect was largely in-significant.

4.3.5 Nitrate content in the root

It is deduced from table 14 that application of the hormones did not show any impact on per cent nitrate content of the root. The interaction effect was also non-significant.

4.3.6 Protein content in the root

The plants exhibited significant response to the treatment, in terms of their per cent protein content (Table 15). The maximum values were recorded in the roots treated with GA_3 (H_1), at all the growth stages, studied.

Table 13. The length (cm), fresh and dry weight (g) of the root, received water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M of GA_3 (H_1), IAA (H_2) or IBA (H_3) through nutrient solution on 7th (R_1) or 14th (R_2) or both 7th and 14th (R_3) days, after the emergence of the seedlings. The sampling was done at 25, 35 and 45 days, after sowing.

Treatments	**Length**			**Fresh weight**			**Dry weight**		
	DAYS AFTER SOWING								
	25	**35**	**45**	**25**	**35**	**45**	**25**	**35**	**45**
Control(C_1)	**11.20**	**16.49**	**19.00**	**1.000**	**1.190**	**1.79**	**0.330**	**0.440**	**0.660**
H_1	14.02	20.91	23.60	1.114	1.462	2.22	0.378	0.483	0.785
H_2	17.31	20.44	25.66	1.111	1.423	2.10	0.376	0.491	0.772
H_3	16.76	21.27	26.92	1.062	1.455	2.03	0.363	0.467	0.750
CD at 5%	**0.55**	**0.65**	**0.78**	**0.043**	**NS**	**0.11**	**NS**	**NS**	**NS**
C_2	12.65	18.39	20.27	1.016	1.294	1.91	0.345	0.441	0.718
C_3	17.00	22.43	27.66	1.114	1.499	2.19	0.380	0.498	0.785
C_4	18.44	21.81	28.25	1.156	1.547	2.26	0.393	0.503	0.805
CD at 5%	**0.55**	**0.65**	**0.76**	**0.043**	**0.115**	**0.11**	**0.016**	**0.023**	**0.034**
R_1	13.99	17.02	22.89	1.007	1.428	2.05	0.362	0.483	0.760
R_2	14.83	18.76	20.47	1.005	1.313	1.95	0.340	0.430	0.698
R_3	19.27	26.84	32.81	1.225	1.598	2.36	0.416	0.528	0.850
CD at 5%	**0.55**	**0.65**	**0.76**	**1.043**	**0.115**	**0.11**	**0.016**	**0.023**	**0.034**
H_1C_2	11.26	16.43	18.94	1.045	1.263	2.01	0.356	0.443	0.731
H_1C_3	14.59	22.21	25.89	1.109	1.573	2.33	0.383	0.504	0.807
H_1C_4	16.20	24.09	25.96	1.188	1.548	2.33	0.396	0.503	0.817
H_2C_2	13.62	18.30	20.82	1.011	1.347	1.88	0.344	0.448	0.713
H_2C_3	18.99	21.53	27.00	1.158	1.411	2.14	0.389	0.510	0.788
H_2C_4	19.32	21.48	29.15	1.165	1.511	2.28	0.395	0.516	0.814
H_3C_2	13.08	20.44	21.04	0.994	1.270	1.84	0.335	0.433	0.711
H_3C_3	17.41	22.54	30.08	1.075	1.513	2.10	0.367	0.479	0.759
H_3C_4	19.80	19.84	29.63	1.117	1.582	2.16	0.388	0.490	0.782
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
H_1R_1	13.33	17.96	22.41	1.073	1.392	2.28	0.367	0.484	0.795
H_1R_2	12.91	17.19	16.46	1.029	1.342	1.96	0.344	0.435	0.697
H_1R_3	15.81	27.58	31.92	1.239	1.651	2.44	0.425	0.530	0.863
H_2R_1	14.50	17.69	22.46	1.292	1.460	2.00	0.369	0.494	0.755
H_2R_2	15.36	17.02	21.16	0.977	1.228	1.96	0.335	0.432	0.69686
H_2R_3	22.07	26.61	23.35	1.265	1.580	2.35	0.425	0.547	0.729
H_3R_1	14.15	15.41	23.79	1.007	1.431	1.89	0.350	0.471	0.700
H_3R_2	16.21	22.08	23.79	1.009	1.369	1.92	0.342	0.424	0.823
H_3R_3	19.93	26.34	33.18	1.170	1.565	2.28	0.398	0.507	0.720
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

C_2R_1	11.53	13.56	16.73	1.967	1.317	1.83	0.333	0.440	0.691
C_2R_2	11.20	15.34	15.69	1.917	1.145	1.72	0.314	0.392	0.648
C_2R_3	15.24	26.27	28.38	1.165	1.419	2.19	0.388	0.492	0.816
C_3R_1	14.01	18.02	25.84	1.063	1.475	2.11	0.366	0.507	0.789
C_3R_2	15.76	19.24	23.21	1.043	1.356	2.01	0.349	0.439	0.711
C_3R_3	21.23	30.02	33.92	1.236	1.665	2.46	0.425	0.547	0.854
C_4R_1	16.44	19.47	26.08	1.142	1.491	2.2	0.387	0.502	0.799
C_4R_2	17.53	21.71	22.52	1.055	1.438	2.11	0.358	0.460	0.735
C_4R_3	21.35	24.23	36.14	1.272	1.711	2.43	0.434	0.546	0.880
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_2R_1$	10.75	12.56	17.03	1.975	1.280	1.97	0.340	0.452	0.720
$H_1C_2R_2$	9.84	13.26	13.30	1.953	1.109	1.72	0.330	0.394	0.656
$H_1C_2R_3$	13.20	23.49	26.50	1.205	1.404	2.35	0.398	0.483	0.817
$H_1C_3R_1$	13.68	19.02	22.46	1.045	1.450	2.26	0.364	0.501	0.815
$H_1C_3R_2$	13.66	16.42	18.89	1.065	1.494	2.13	0.350	0.447	0.714
$H_1C_3R_3$	16.44	31.19	36.31	1.218	1.775	2.61	0.436	0.565	0.893
$H_1C_4R_1$	15.56	22.29	27.73	1.199	1.447	2.60	0.397	0.500	0.851
$H_1C_4R_2$	15.24	21.91	17.20	1.070	1.423	2.03	0.351	0.464	0.722
$H_1C_4R_3$	17.80	28.07	32.95	1.293	1.773	2.35	0.441	0.544	0.879
$H_2C_2R_1$	11.74	13.04	16.63	1.979	1.315	1.90	0.334	0.444	0.689
$H_2C_2R_2$	11.34	14.95	14.93	1.863	1.116	1.64	0.300	0.387	0.620
$H_2C_2R_3$	17.77	26.92	30.90	1.191	1.609	2.11	0.400	0.515	0.831
$H_2C_3R_1$	15.48	18.93	26.05	1.128	1.678	2.01	0.380	0.528	0.789
$H_2C_3R_2$	17.39	19.34	24.30	1.039	1.104	2.03	0.350	0.443	0.717
$H_2C_3R_3$	24.11	26.31	30.66	1.308	1.451	2.38	0.437	0.558	0.858
$H_2C_4R_1$	16.28	21.10	24.72	1.170	1.387	2.09	0.393	0.511	0.787
$H_2C_4R_2$	17.35	16.76	24.26	1.028	1.465	2.20	0.355	0.467	0.753
$H_2C_4R_3$	24.34	26.59	38.48	1.296	1.680	2.54	0.436	0.569	0.904
$H_3C_2R_1$	12.11	15.09	16.53	1.946	1.357	1.63	0.326	0.425	0.665
$H_3C_2R_2$	12.40	17.82	18.83	1.935	1.211	1.79	0.312	0.396	0.668
$H_3C_2R_3$	14.74	28.41	27.75	1.100	1.244	2.10	0.367	0.477	0.800
$H_3C_3R_1$	12.86	16.10	29.02	1.017	1.298	2.06	0.354	0.493	0.764
$H_3C_3R_2$	16.24	21.95	26.44	1.026	1.471	1.87	0.345	0.426	0.701
$H_3C_3R_3$	23.13	32.56	34.79	1.182	1.770	2.38	0.402	0.517	0.811
$H_3C_4R_1$	17.48	15.03	25.81	1.056	1.639	1.99	0.371	0.495	0.758
$H_3C_4R_2$	20.00	26.47	26.10	1.066	1.426	2.11	0.370	0.449	0.731
$H_3C_4R_3$	21.92	1804.	36.99	1.228	1.680	2.39	0.424	0.526	0.857
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 14. The level of nitrate reductase (NRA; m moles $g^{-1}h^{-1}fw$) and nitrate content ($\mu g \times 10^{-3} g^{-1}$) of the root, received water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M of GA_3 (H_1), IAA (H_2) or IBA (H_3) through nutrient solution on 7th (R_1) or 14th (R_2) or both 7th and 14th (R_3) days, after the emergence of the seedlings. The sampling was done at 25, 35 and 45 days, after sowing.

Treatments	NRA			Nitrate		
	DAYS AFTER SOWING					
	25	35	45	25	35	45
Control(C_1)	**1.025**	**1.005**	**0.905**	**150**	**122**	**119**
H_1	1.255	1.257	1.340	160	131	127
H_2	1.129	1.081	0.948	164	135	130
H_3	1.050	1.020	0.901	159	129	125
CD at 5%	**0.044**	**0.041**	**0.040**	**NS**	**NS**	**NS**
C_2	1.024	0.976	0.917	160	131	127
C_3	1.200	1.198	1.039	165	135	131
C_4	1.210	1.183	1.026	167	137	132
CD at 5%	**0.044**	**0.041**	**0.040**	**NS**	**NS**	**NS**
R_1	1.056	1.051	0.976	159	130	126
R_2	1.059	1.022	0.891	160	131	127
R_3	1.319	1.284	1.166	163	133	129
CD at 5%	**0.044**	**0.041**	**0.040**	**NS**	**NS**	**NS**
H_1C_2	1.125	1.086	1.048	159	130	126
H_1C_3	1.346	1.379	1.213	166	136	131
H_1C_4	1.295	1.306	1.142	166	136	131
H_2C_2	1.021	0.940	0.877	166	137	132
H_2C_3	1.193	1.151	0.986	168	138	133
H_2C_4	1.193	1.152	0.980	172	142	136
H_3C_2	0.925	0.902	0.827	155	126	123
H_3C_3	1.082	1.166	0.920	163	133	129
H_3C_4	1.143	1.091	0.956	164	135	130
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
H_1R_1	1.157	1.191	1.065	159	130	126
H_1R_2	1.176	1.137	1.002	159	130	126
H_1R_3	1.433	1.444	1.336	162	132	128
H_2R_1	1.038	0.988	0.945	163	133	129
H_2R_2	1.019	0.984	0.852	163	133	129
H_2R_3	1.329	1.270	1.046	166	136	131
H_3R_1	0.973	0.975	0.918	157	128	124
H_3R_2	0.982	0.946	0.819	157	128	124
H_3R_3	1.195	1.138	0.965	161	131	127
CD at 5%	**NS**	**NS**	**0.069**	**NS**	**NS**	**NS**

C_2R_1	0.961	0.963	0.877	159	130	126
C_2R_2	0.923	0.877	0 797	162	133	128
C_2R_3	1.188	1.088	1.078	159	130	126
C_3R_1	1.096	1.098	1.021	164	134	129
C_3R_2	1.109	1.085	0.940	162	132	128
C_3R_3	1.395	1.142	1.157	170	140	135
C_4R_1	1.122	1.093	1.029	166	136	131
C_4R_2	1.144	1.105	0.936	164	135	130
C_4R_3	1.374	1.352	1.136	172	142	136
CD at 5%	**NS**	**0.071**	**NS**	**NS**	**NS**	**NS**
$H_1C_2R_1$	1.049	1.048	0.957	159	129	125
$H_1C_2R_2$	1.051	1.009	0.911	161	131	127
$H_1C_2R_3$	1.275	1.202	1.277	159	130	126
$H_1C_3R_1$	1.185	1.267	1.108	164	135	130
$H_1C_3R_2$	1.245	1.207	1.084	164	135	130
$H_1C_3R_3$	1.609	1.662	1.446	168	138	133
$H_1C_4R_1$	1.236	1.257	1.130	164	134	129
$H_1C_4R_2$	1.233	1.194	1.011	163	133	129
$H_1C_4R_3$	1.415	1.467	1.286	171	140	135
$H_2C_2R_1$	0.950	0.953	0.853	164	135	130
$H_2C_2R_2$	0.856	0.783	0.739	169	139	134
$H_2C_2R_3$	1.258	1.084	1.039	165	135	131
$H_2C_3R_1$	1.071	1.010	1.002	166	137	132
$H_2C_3R_2$	1.104	1.085	0.915	162	132	128
$H_2C_3R_3$	1.339	1.357	1.039	174	144	138
$H_2C_4R_1$	1.093	1.001	0.980	171	140	135
$H_2C_4R_2$	1.097	1.086	0.903	171	140	135
$H_2C_4R_3$	1.390	1.369	1.059	175	145	139
$H_3C_2R_1$	0.883	0.889	0.829	155	126	122
$H_3C_2R_2$	0.863	0.838	0.741	158	129	125
$H_3C_2R_3$	1.030	0.979	0.917	154	125	121
$H_3C_3R_1$	1.030	1.016	0.954	160	130	126
$H_3C_3R_2$	0.978	0.964	0.821	161	131	127
$H_3C_3R_3$	1.238	1.218	0.984	169	138	133
$H_3C_4R_1$	1.007	1.020	0.978	163	133	129
$H_3C_4R_2$	1.104	1.035	0.895	160	131	127
$H_3C_4R_3$	1.318	1.218	0.994	171	141	135
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

An increase in the concentration of the hormones significantly improved the protein level of the roots, however, the two higher concentrations (C_3 and C_4) gave the values at par with each other. The time of application of the hormone (R_1, R_2 or R_3) was some what equally effective on the protein content. This parameter interacted with treatment variants in-significantly.

4.3.7 Soluble carbohydrate content in the root

The treatment affected soluble fraction of the carbohydrates, significantly (Table 15). Among the hormones, GA_3 (H_1) was most effective and induced an effect significantly different form those of other hormones. It was followed by IAA (H_2). The values of soluble carbohydrate increased with the age of the plant. In general, 10^{-7} M (C_3) of the hormones proved best, even though it was at par with 10^{-5} M (C_4) at the early stages of growth (25 and 35 DAS). It is evident that the hormones should be applied both on day 7 and 14 (R_3), to generate a significant impact. All the treatment factors intracted with this parameter non-significantly.

4.3.8 Insoluble carbohydrate content in the root

The per cent content of insoluble carbohydrate increased significantly by the treatment (Table 15). However, as the plants aged it generally decreased. GA_3 (H_1) was far superior in its effect than the other hormones (H_2 and H_3) whose effect was comparable with each other. The hormone concentration 10^{-7} M (C_3) proved best, even though its effect was comparable with that of the highest concentration (10^{-5} M). The best possible time for the application of the hormone is repeated application on day 7 and 14 (R_3). All possible interactions were non-significant.

Table 15. The per cent protein, soluble and insoluble carbohydrates of the root, received water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M of GA_3 (H_1), IAA (H_2) or IBA (H_3) through nutrient solution on 7th (R_1) or 14th (R_2) or both 7th and 14th (R_3) day, after the emergence of the seedlings. The sampling was done at 25, 35 and 45 days, after sowing (DAS).

Treatments	Protein			Sol. carbohydrate			Insol. carbohydrate		
	DAYS AFTER SOWING								
	25	35	45	25	35	45	25	35	45
Control(C1)	**16.05**	**15.77**	**14.56**	**3.659**	**4.900**	**5.000**	**44.95**	**36.00**	**38.50**
H_1	18.98	17.50	16.30	4.546	6.322	6.326	53.59	44.70	34.35
H_2	16.09	17.47	15.45	4.172	5.552	5.688	50.75	41.08	32.28
H_3	17.79	16.01	14.95	3.984	5.359	5.447	48.57	39.56	30.99
CD at 5%	**1.20**	**1.10**	**1.14**	**0.184**	**0.223**	**0.220**	**2.25**	**2.49**	**1.46**
C_2	16.41	16.55	16.80	4.032	5.535	5.621	48.22	39. 80	31.09
C_3	18.29	18.35	17.75	4.374	5.955	6.039	52.21	43.26	33.54
C_4	19.18	19.14	18.10	4.306	5.743	5.801	52.28	42.27	32.99
CD at 5%	**1.20**	**1.10**	**1.14**	**0.184**	**0.223**	**0.220**	**2.25**	**2.49**	**1.46**
R_1	18.72	18.19	16.69	4.333	5.786	5.799	51.08	42.94	33.24
R_2	18.57	18.20	16.78	3.785	5.136	5.215	45.76	37.34	28.92
R_3	19.58	18.70	17.35	4.614	6.312	6.447	56.07	45.06	34.46
CD at 5%	**1.20**	**NS**	**1.14**	**0.184**	**0.223**	**0.220**	**2.25**	**2.49**	**1.46**
H_1C_2	18.00	17.50	16.25	4.382	6.109	6.110	50.67	42.69	32.73
H_1C_3	19.20	18.25	17.20	4.740	6.623	6.598	55.01	46.44	35.52
H_1C_4	19.74	18.70	17.03	4.606	6.235	6.269	55.08	44.97	34.79
H_2C_2	15.91	16.70	15.50	3.956	5.302	5.470	48.03	38.56	30.71
H_2C_3	18.30	17.20	15.10	4.299	5.733	5.921	52.15	42.82	33.31
H_2C_4	19.07	18.05	17.08	4.261	5.620	5.673	52.08	41.86	32.82
H_3C_2	15.31	16.30	17.25	3.818	5.194	5.283	46.56	38.15	29.81
H_3C_3	17.36	16.42	16.37	4.083	5.509	5.597	49.48	40.53	31.79
H_3C_4	17.72	16.70	15.32	4.051	5.375	5.461	49.6 1	39.99	31.35
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
H_1R_1	19.31	18.03	17.05	4.660	6.245	6.235	54.07	45.93	35.40
H_1R_2	16.21	15.20	16.00	4.000	5.689	5.690	47.76	39.47	30.26
H_1R_3	19.41	17.30	16.20	5.069	7.032	7.052	58.94	48.71	37.37
H_2R_1	18.01	17.05	16.00	4.247	5.687	5.714	50.76	42.43	32.82
H_2R_2	15.95	16.05	15.25	3.700	4.818	4.995	44.94	36.01	28.34
H_2R_3	19.00	17.25	16.45	4.569	6.150	6.355	56.57	44.80	35.68
H_3R_1	17.06	16.85	15.85	4.091	5.426	5.448	48.41	40.46	31.51
H_3R_2	15.15	14.95	13.90	3.654	4.899	4.960	44.60	36.55	28.15
H_3R_3	18.17	17.90	16.80	4.206	5.753	5.933	52.70	41.67	33.30
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

C_2R_1	16.87	15.90	14.90	4.031	5.424	5.441	47.58	40.04	31.05
C_2R_2	14.00	15.00	14.50	3.584	4.936	5.002	43.30	35.28	27.48
C_2R_3	18.35	17.00	16.55	4.540	6.247	6.421	54.56	44.09	34.73
C_3R_1	19.14	18.01	17.05	4.516	6.058	6.057	53.33	44.99	34.82
C_3R_2	15.86	14.90	13.07	3.874	5.304	5.375	46.53	38.86	29.52
C_3R_3	19.86	18.50	17.22	4.732	6.573	6.684	66.78	45.93	36.28
C_4R_1	19.16	18.10	17.12	4.451	5.876	5.900	52.33	43.79	33.85
C_4R_2	16.84	15.80	14.70	3.895	5.168	5.268	47.64	37.89	29.76
C_4R_3	19.35	18.30	17.35	4.572	6.186	6.236	56.86	45.15	35.35
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_2R_1$	18.88	17.80	16.68	4.344	5.820	5.833	50.41	43.10	33.22
$H_1C_2R_2$	15.12	15.00	14.00	3.799	5.530	5.518	44.93	37.53	28.87
$H_1C_2R_3$	19.01	18.50	17.00	5.004	6.979	6.979	56.67	47.45	36.10
$H_1C_3R_1$	19.77	18.50	17.35	4.805	6.497	6.439	55.78	47.69	36.72
$H_1C_3R_2$	17.30	16.50	15.39	4.117	5.957	5.897	48.64	40.77	31.04
$H_1C_3R_3$	19.74	18.70	17.42	5.298	7.414	7.459	60.61	50.85	38.79
$H_1C_4R_1$	19.01	18.02	17.40	4.830	6.419	6.434	56.02	46.98	36.25
$H_1C_4R_2$	18.20	17.50	16.38	4.084	5.581	5.655	49.70	40.10	30.88
$H_1C_4R_3$	19.00	18.02	17.42	4.904	6.704	6.719	59.53	47.82	37.23
$H_2C_2R_1$	16.61	16.60	15.90	3.959	5.367	5.392	47.27	39.41	30.66
$H_2C_2R_2$	15.95	14.99	13.95	3.428	4.468	4.657	41.49	32.37	26.25
$H_2C_2R_3$	17.92	16.70	16.05	4.482	6.073	6.362	55.32	43.91	35.22
$H_2C_3R_1$	19.86	18.95	17.82	4.403	5.954	5.981	53.12	44.57	34.34
$H_2C_3R_2$	17.28	17.25	16.67	3.852	5.011	5.208	46.45	38.76	29.39
$H_2C_3R_3$	19.50	18.32	17.00	4.642	6.234	6.575	56.88	45.13	36.21
$H_2C_4R_1$	18.12	17.42	16.05	4.379	5.741	5.769	51.87	43.32	33.45
$H_2C_4R_2$	17.21	16.94	15.85	3.820	4.975	5.121	46.89	36.90	29.39
$H_2C_4R_3$	16.21	15.84	14.92	4.583	6.144	6.130	57.50	45.35	35.61
$H_3C_2R_1$	17.22	16.06	15.07	3.789	5.086	5.098	45.04	37.60	29.28
$H_3C_2R_2$	18.00	17.65	16.68	3.529	4.808	4.829	42.96	35.93	27.31
$H_3C_2R_3$	19.15	18.98	17.90	4.135	5.689	5.921	51.68	40.91	32.86
$H_3C_3R_1$	17.00	16.92	15.60	4.342	5.742	5.750	51.10	42.72	33.41
$H_3C_3R_2$	16.95	15.86	14.00	3.652	4.943	5.022	44.49	37.06	28.12
$H_3C_3R_3$	17.91	16.07	15.05	4.254	5.860	6.019	52.85	41.81	33.83
$H_3C_4R_1$	18.09	17.00	16.70	4.142	5.469	5.496	49.11	41.06	31.86
$H_3C_4R_2$	17.90	17.67	16.55	3.782	4.946	5.028	46.34	36.65	29.01
$H_3C_4R_3$	18.10	17.12	16.25	4.228	5.710	5.859	54.57	42.27	33.20
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

4.3.9 Nitrogen, phosphorus and potassium contents in the root

The values for all these elements increased significantly by the treatment (Table 16). However, as the growth progressed, their per cent content decreased. Gibberellic acid (H_1) was most prominent in its effect by increasing the content of these nutrients to a significantly highest level in the roots and was closely followed by IAA (H_2). The per cent NPK contents exhibited an increasing order with an increase in the level of the hormones, however, the two higher concentrations (C_3 and C_4) were at par with each other in their effect. The repeated application (R_3) of the hormone proved best though the values were statistically equal with that of R_1, at majority of the stages of growth. All possible interactions were non-significant.

4.3.10 Shoot length per plant

It is evident from table 17 that the shoot length was significantly enhanced by the incorporation of the hormones to the nutrient solution. GA_3 (H_1) was very prominent in its effect generating the values far superior than any other hormones (H_2 and H_1). Considering the hormone concentrations, the two higher levels (C_3 and C_4) proved best whose effect was statistically at par, at 25 and 45 DAS. The shoot length was improved to a maximum extent if its roots received the hormones twice (R_3). H_1C_4 and H_1R_3, interacted significantly producing maximum shoot length.

4.3.11 Shoot fresh weight per plant

The treatment significantly enhanced the fresh weight of the shoot as compared with the control (Table 17). The maximum values were

Table 16. The per cent nitrogen, phosphorus and potassium in the root, received water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M of GA_3 (H_1), IAA (H_2) or IBA (H_3) through nutrient solution on 7th (R_1) or 14th (R_2) or both 7th and 14th (R_3) day, after the emergence of the seedlings. The sampling was done at 25, 35 and 45 days, after the sowing.

Treatments	Nitrogen			Phosphorus			Potassium		
	DAYS AFTER SOWING								
	25	35	45	25	35	45	25	35	45
Control (C_1)	**3.54**	**3.17**	**3.01**	**0.425**	**0.400**	**0.378**	**2.77**	**2.55**	**2.44**
H_1	4.03	3.76	3.55	0.503	0.473	0.448	3.25	3.05	2.90
H_2	3.88	3.62	3.42	0.484	0.454	0.432	3.13	2.94	2.79
H_3	3.66	3.42	3.22	0.458	0.430	0.407	2.96	2.78	2.63
CD at 5%	0.197	**0.181**	**0.186**	**0.023**	**0.021**	**0.022**	**0.154**	**0.141**	**0.144**
C_2	**3.60**	3.36	3.16	0.450	0.423	0.400	2.91	2.73	2.78
C_3	3.91	3.65	3.44	0.489	0.459	0.435	3.16	2.97	2.92
C_4	4.06	3.79	3.58	0.506	0.475	0.452	3.27	2.07	2.99
CD at 5%	**0.197**	**0.181**	**0.186**	**0.023**	**0.021**	**0.022**	**0.154**	**0.141**	**0.144**
R_1	3.99	3.72	3.51	0.498	0.468	0.443	3.22	3.02	2.86
R_2	3.45	3.22	3.05	0.431	0.404	0.385	2.78	2.61	2.48
R_3	4.13	3.86	3.63	0.516	0.485	0.459	3.34	3.13	2.97
CD at 5%	**0.197**	**0.181**	**0.186**	**0.023**	**0.021**	**0.022**	**0.154**	**0.141**	**0.144**
H_1C_2	3.86	3.60	3.41	0.482	0.452	0.430	3.11	2.92	2.78
H_1C_3	4.07	3.80	3.57	0.509	0.478	0.452	3.29	3.09	2.92
H_1C_4	4.16	3.88	3.66	0.520	0.488	0.462	3.36	3.15	2.99
H_2C_2	3.52	3.29	3.08	0.441	0.414	0.391	2.85	2.68	2.52
H_2C_3	3.91	3.65	3.45	0.489	0.459	0.436	3.16	2.97	2.81
H_2C_4	4.20	3.91	3.73	0.522	0.490	0.469	3.38	3.16	3.03
H_3C_2	3.42	3.19	2.99	0.428	0.402	0.379	2.76	2.60	2.45
H_3C_3	3.75	3.50	3.31	0.469	0.440	0.418	3.03	2.84	2.70
H_3C_4	3.82	3.56	3.36	0.477	0.448	0.425	3.08	2.89	2.74
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
H_1R_1	4.25	3.97	3.75	0.531	0.499	0.473	3.43	3.22	3.06
H_1R_2	3.56	3.32	3.14	0.445	0.417	0.397	2.87	2.70	2.56
H_1R_3	4.28	3.99	3.75	0.535	0.503	0.475	3.46	3.25	3.07
H_2R_1	4,00	3.73	3.52	0.499	0.468	0.445	3.22	3.03	2.87
H_2R_2	3.41	3.18	3.02	0.426	0.400	0.380	2.75	2.58	2.46
H_2R_3	4.22	3.94	3.72	0.527	0.495	0.470	3.41	3.20	3.04
H_3R_1	3.71	3.47	3.25	0.465	0.437	0.412	3.00	2.82	2.66
H_3R_2	3.38	3.15	2.99	0.422	0.396	0.377	2.72	2.56	2.43
H_3R_3	3.90	3.64	3.42	0.487	0.457	0.433	3.15	2.95	2.80
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

C_2R_1	3.68	3.43	3.23	0.459	0.431	0.409	2.97	2.79	2.64
C_2R_2	3.19	2.98	2.81	0.399	0.374	0.335	2.58	2.42	2.29
C_2R_3	3.93	3.67	3.44	0.492	0.462	0.136	3.18	2.99	2.82
C_3R_1	4.06	3.79	3.56	0.508	0.477	0.451	3.28	3.08	2.91
C_3R_2	3.50	3.26	3.09	0.437	0.410	0.390	2.82	2.65	2.52
C_3R_3	4.18	3.90	3.67	0.522	0.490	0.465	3.37	3.17	3.00
C_4R_1	4.22	3.94	3.73	0.527	0.595	0.470	3.41	3.20	3.64
C_4R_2	3.66	3.42	3.24	0.457	0.428	0.409	2.95	2.77	2.64
C_4R_3	4.29	4.00	3.78	0.535	0.502	0.477	3.46	3.25	3.08
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_2R_1$	4.01	3.74	3.54	0.499	0.468	0.447	3.23	3.03	2.89
$H_1C_2R_2$	3.37	3.15	2.98	0.421	0.395	0.376	2.72	2.55	2.43
$H_1C_2R_3$	4.20	3.92	3.70	0.524	0.492	0.467	3.39	3.18	3.02
$H_1C_3R_1$	4.16	3.89	3.64	0.522	0.491	0.462	3.37	3.17	2.98
$H_1C_3R_2$	3.71	3.46	3.29	0.462	0.433	0.414	2.99	2.80	2.67
$H_1C_3R_3$	4.34	4.05	3.79	0.543	0.510	0.481	3.51	3.30	3.11
$H_1C_4R_1$	4.59	4.28	4.06	0.572	0.536	0.511	3.71	3.47	3.30
$H_1C_4R_2$	3.60	3.36	3.15	0.450	0.423	0.400	2.91	2.73	2.58
$H_1C_4R_3$	4.29	4.01	3.76	0.537	0.505	0.476	3.47	3.26	3.08
$H_2C_2R_1$	3.63	3.39	3.19	0.454	0.427	0.404	2.94	2.76	2.61
$H_2C_2R_2$	2.98	2.78	2.60	0.373	0.351	0.330	2.41	2.26	2.13
$H_2C_2R_3$	3.95	3.69	3.45	0.495	0.465	0.438	3.20	3.01	22.83
$H_2C_3R_1$	4.02	3.76	3.53	0.503	0.473	0.447	3.25	3.05	2.89
$H_2C_3R_2$	3.53	3.29	3.13	0.440	0.413	0.394	2.85	2.67	2.55
$H_2C_3R_3$	4.19	3.91	3.68	0.523	0.492	0.466	3.38	3.18	3.01
$H_2C_4R_1$	4.33	4.04	3.85	0.539	0.505	0.484	3.48	3.27	3.13
$H_2C_4R_2$	3.73	3.47	3.32	0.464	0.435	0.417	3.00	2.81	2.69
$H_2C_4R_3$	4.53	4.22	3.03	0.564	0.529	0.506	3.64	3.42	3.27
$H_3C_2R_1$	3.39	3.17	2.96	0.424	0.399	0.376	2.74	2.58	2.43
$H_3C_2R_2$	3.22	3.01	2.85	0.402	0.377	0.359	2.60	2.44	2.32
$H_3C_2R_3$	3.64	3.40	3.17	0.457	0.430	0.403	2.95	2.78	2.60
$H_3C_3R_1$	3.99	3.73	3.52	0.499	0.468	0.445	3.22	3.02	2.87
$H_3C_3R_2$	3.26	3.04	2.86	0.407	0.383	0.362	2.63	2.47	2.34
$H_3C_3R_3$	4.01	3.74	3.55	0.500	0.469	0.447	3.23	3.03	2.89
$H_3C_4R_1$	3.75	3.51	3.27	0.471	0.443	0.416	3.04	2.86	2.69
$H_3C_4R_2$	3.66	3.41	3.25	0.456	0.427	0.409	2.94	2.76	2.64
$H_3C_4R_3$	4.04	3.77	3.56	0.504	0.473	0.449	3.26	3.06	2.90
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

recorded in the plants which received GA_3 (H_1) followed by IAA (H_2). The higher concentrations (C_3 and C_4) of the hormones proved more effective but the effect was statistically equal, at 35 and 45 DAS. The plants gave maximum response to repeated application (R_3). All the interactions were non-significant.

4.3.12 Shoot dry weight per plant

The shoot dry weight also exhibited significant response to the hormonal treatment and followed the same pattern as that of fresh weight (Table 17).

4.3.13 Leaf number per plant

Table 18 reveals that the plants raised with the exogenously applied hormones had more leaves than the control, at all the stages of growth, studied. Significantly higher values were noted with GA_3 (H_1). A linear increase in leaf number is recorded with the increase in the hormonal level. The addition of hormones twice (R_3) proved superior than single (R_1 or R_2) application. All the interactions were non-significant.

4.3.14 Leaf nitrate redutase activity (NRA)

NRA gave significant response to the treatment where maximum values were recorded with GA_3 (Table 18). The activity of the enzyme increased with an increase in the level of hormone but the effect of C_3 and C_4 was comparable. Repeated application (R_3) of the hormones was more effective than single applications (R_1 or R_2). The interaction effect was non-significant.

Table 17. The length (cm), fresh and dry weight (g) of the shoot of the plants, received water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M of GA_3 (H_1), IAA (H_2) or IBA (H_3) through nutrient solution on 7th (R_1) or 14th (R_2) or both 7th and 14th (R_3) days, after the emergence of the seedlings. The sampling was done at 25, 35 and 45 days, after sowing.

Treatments	Length			Fresh weight			Dry weight		
	DAYS AFTER SOWING								
	25	35	45	25	35	45	25	35	45
Control(C_1)	**10.25**	**25.50**	**32.00**	**0.735**	**0.995**	**1.375**	**0.225**	**0.305**	**0.550**
H_1	13.07	38.50	47.02	0.915	1.319	2.089	0.286	0.399	0.639
H_2	11.96	29.59	38.41	0.851	1.175	1.902	0.262	0.362	0.587
H_3	11.62	30.83	34.99	0.785	1.129	1.790	0.251	0.353	0.553
CD at 5%	**0.46**	**1.46**	**1.66**	**0.333**	**0.047**	**0.115**	**0.012**	**0.016**	**0.022**
C_2	10.86	29.40	35.94	0.758	1.102	1.760	0.236	0.341	0.545
C_3	12.85	36.08	41.62	0.862	1.254	2.012	0.276	0.386	0.611
C_4	12.95	33.44	42.86	0.931	1.266	2.009	0.287	0.387	0.623
CD at 5%	**0.46**	**1.46**	**1.66**	**0.033**	**0.047**	**0.115**	**0.012**	**0.016**	**0.022**
R_1	10.83	28.27	36.82	0.746	1.125	1.831	0.233	0.347	0.564
R_2	11.49	32.27	37.90	0.798	1.119	1.807	0.249	0.341	0.545
R_3	14.34	38.37	45.70	1.007	1.378	2.123	0.316	0.426	0.670
CD at 5%	**0.46**	**1.46**	**1.66**	**0.333**	**0.047**	**0.115**	**0.012**	**0.016**	**0.022**
H_1C_2	11.55	35.54	39.65	0.786	1.176	1.867	0.253	0.360	0.586
H_1C_3	12.80	41.10	49.39	0.931	1.385	2.216	0.296	0.421	0.663
H_1C_4	13.86	38.86	52.03	1.009	1.396	2.183	0.310	0.415	0.667
H_2C_2	10.76	26.70	33.66	0.785	1.076	1.767	0.234	0.333	0.541
H_2C_3	12.36	32.19	40.71	0.859	1.236	1.991	0.270	0.378	0.605
H_2C_4	12.77	29.89	40.85	0.910	1.217	1.948	0.282	0.376	0.616
H_3C_2	10.26	25.96	34.53	0.705	1.061	1.645	0.222	0.329	0.508
H_3C_3	12.39	34.95	34.76	0.776	1.140	1.828	0.262	0.369	0.566
H_3C_4	12.22	31.57	35.70	0.874	1.185	1.895	0.268	0.370	0.586
CD at 5%	**NS**	**NS**	**2.88**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
H_1R_1	11.37	32.66	43.32	0.791	1.201	1.987	0.248	0.367	0.609
H_1R_2	12.22	37.55	44.36	0.869	1.255	1.900	0.271	0.366	0.586
H_1R_3	15.62	45.28	53.38	0.086	1.502	1.379	0.340	0.464	0.721
H_2R_1	10.75	25.61	32.30	0.739	1.115	1.828	0.233	0.345	0.558
H_2R_2	11.22	26.78	37.97	0.784	1.051	1.778	0.243	0.327	0.534
H_2R_3	13.93	36.38	44.96	1.031	1.358	2.101	0.310	0.415	0.670
H_3R_1	10.37	26.54	34.83	0.708	1.060	1.737	0.220	0.330	0.525
H_3R_2	11.02	32.48	31.37	0.742	1.031	1.743	0.234	0.329	0.517
H_3R_3	13.47	33.46	38.78	0.905	1.274	1.889	0.298	0.399	0.618
CD at 5%	**NS**	**NS**	**2.881**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

C_2R_1	9.93	25.51	32.11	0.641	1.019	1.614	0.207	0.317	0.507
C_2R_2	9.86	27.02	33.06	0.685	1.013	1.699	0.214	0.308	0.497
C_2R_3	12.78	35.67	42.66	0.949	1.275	1.966	0.287	0.398	0.631
C_3R_1	11.10	30.55	39.25	0.750	1.192	1.959	0.238	0.364	0.590
C_3R_2	12.12	36.22	39.80	0.840	1.159	1.847	0.263	0.352	0.558
C_3R_3	15.32	41.46	45.81	0.996	1.410	2.230	0.326	0.443	0.686
C_4R_1	11.46	28.75	39.10	0.847	1.164	1.479	0.255	0.361	0.596
C_4R_2	12.47	33.57	40.85	0.869	1.186	1.875	0.271	0.363	0.582
C_4R_3	14.91	37.99	48.64	1.077	1.449	2.171	0.334	0.436	0.693
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_2R_1$	9.92	30.18	36.22	0.696	1.028	1.746	0.235	0.319	0.550
$H_1C_2R_2$	10.85	33.29	35.64	0.742	1.145	1.719	0.228	0.332	0.536
$H_1C_2R_3$	13.86	43.13	47.08	0.920	1.356	2.135	0.296	0.430	0.671
$H_1C_3R_1$	11.46	35.48	44.68	0.750	1.318	2.098	0.234	0.391	0.629
$H_1C_3R_2$	12.97	38.76	47.79	0.945	1.342	1.965	0.294	0.384	0.601
$H_1C_3R_3$	16.98	49.05	55.69	1.158	1.493	2.585	0.359	0.489	0.758
$H_1C_4R_1$	12.73	32.32	49.05	0.925	1.255	2.118	0.275	0.390	0.646
$H_1C_4R_2$	12.82	40.59	49.66	0.921	1.278	2.017	0.292	0.381	0.621
$H_1C_4R_3$	16.02	43.67	57.38	1.180	1.657	2.416	0.364	0.474	0.735
$H_2C_2R_1$	10.34	23.32	29.53	0.626	1.022	1.575	0.202	0.321	0.508
$H_2C_2R_2$	9.15	22.01	32.01	0.669	1.931	1.668	0.208	0.288	0.476
$H_2C_2R_3$	12.81	34.75	39.44	1.059	1.258	2.059	0.291	0.390	0.639
$H_2C_3R_1$	10.79	27.34	33.93	0.757	1.168	1.931	0.240	0.366	0.585
$H_2C_3R_2$	11.92	30.75	41.07	0.819	1.091	1.868	0.256	0.340	0.551
$H_2C_3R_3$	14.37	38.47	47.13	1.000	1.450	2.175	0.312	0.429	0.679
$H_2C_4R_1$	11.11	26.17	33.44	0.833	1.153	1.977	0.256	0.348	0.583
$H_2C_4R_2$	12.58	27.59	40.82	0.864	1.131	1.799	0.264	0.353	0.575
$H_2C_4R_3$	14.61	35.90	48.30	1.033	1.366	2.068	0.327	0.425	0.692
$H_3C_2R_1$	9.53	23.01	30.57	0.601	1.005	1.522	0.185	0.310	0.461
$H_3C_2R_2$	9.58	25.75	31.54	0.646	0.964	1.709	0.207	0.303	0.480
$H_3C_2R_3$	11.68	29.13	41.48	0.868	1.213	1.705	0.275	0.375	0.582
$H_3C_3R_1$	11.06	28.83	39.13	0.741	1.091	1.847	0.242	0.334	0.556
$H_3C_3R_2$	11.48	39.17	30.53	0.756	1.042	1.709	0.239	0.331	0.521
$H_3C_3R_3$	14.63	36.86	34.61	0.830	1.286	1.930	0.305	0.411	0.620
$H_3C_4R_1$	10..53	27.78	34.80	0.782	1.084	1.843	0.233	0.345	0.558
$H_3C_4R_2$	12.01	32.53	32.05	0.823	1.148	1.811	0.257	0.354	0.549
$H_3C_4R_3$	14.11	34.40	40.24	1.017	1.323	2.031	0.313	0.411	0.653
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

4.3.15 Nitrate content in the shoot

The nitrate level exhibited no impact of the treatment, therefore, the shoot nitrate content of the plants, receiving hormones, remained at the same level as that of the control (Table 18).

4.3.16 Protein content in the shoot

The shoot exhibited significant response to the treatment where all the hormones were equally effective (Table 19). The increase in the concentrations of the hormone linearly increased the protein level but statistically it was at par with each other. As regards the time of application, it may be supplied once (R_1 or R_2) or twice (R_3), the response is comparable. All the interactions were non-significant.

4.3.17 Soluble and insoluble carbohydrate contents in the shoot

Table 19 shows that the soluble and insoluble carbohydrates increased significantly by the treatment where GA_3 (H_1) proved superior than the other hormones (H_2 and H_3). Statistically equal, higher values were recorded by the supply of either of the higher concentrations of the hormones (C_3 and C_4). The hormonal application twice (R_3) was far superior than single applications (R_1 or R_2). Various factors interacted non-significantly.

4.3.18 Nitrogen, phosphorus and potassium contents in the shoot

Throughout the study, like that of the root, the nutrient status of the shoot receiving hormones was superior than that of the control (Table 20). The pattern of response to various factors of the treatment was very close to that of the root (page 50).

Table 18. The leaf number, level of nitrate reductase (NRA; m moles $g^{-1}h^{-1}fw$) in the leaves and the nitrate content ($\mu g \times 10^{-3} g^{-1}$) in the shoot of the plants, received water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M of GA_3 (H_1), IAA (H_2) or IBA (H_3) through nutrient solution on 7th (R_1) or 14th (R_2) or both 7th and 14th (R_3) days, after the emergence of the seedlings. The sampling was done at 25, 35 and 45 days, after sowing.

Treatments	Leaf number			NRA			Nitrate		
	DAYS AFTER SOWING								
	25	35	45	25	35	45	25	35	45
Control(C_1)	**4.00**	**6.02**	**8.15**	**0.885**	**0.770**	**0.750**	**167**	**132**	**123**
H_1	5.38	7.63	10.14	0.994	0.896	0.975	181	140	129
H_2	4.34	6.82	8.85	0.904	0.812	0.791	187	143	131
H_3	4.36	6.65	8.69	0.846	0.758	0.750	179	138	128
CD at 5%	**0.23**	**0.25**	**0.37**	**0.034**	**0.031**	**0.035**	**NS**	**NS**	**NS**
C_2	4.30	6.48	8.55	0.827	0.741	0.778	181	140	129
C_3	4.70	7.10	9.33	0.953	0.858	0.882	188	144	132
C_4	5.08	7.51	9.79	0.964	0.867	0.864	191	146	133
CD at 5%	**0.23**	**0.25**	**0.37**	**0.034**	**0.031**	**0.035**	**NS**	**NS**	**NS**
R_1	4.50	7.06	8.71	0.865	0.772	0.812	180	139	128
R_2	4.39	6.14	8.54	0.838	0.756	0.755	181	140	129
R_3	5.19	7.89	10.42	1.041	0.939	0.950	185	142	130
CD at 5%	**0.23**	**0.25**	**0.37**	**0.034**	**0.031**	**0.035**	**NS**	**NS**	**NS**
H_1C_2	4.91	7.07	9.37	0.900	0.809	0.898	180	139	128
H_1C_3	5.43	7.74	10.39	1.057	0.955	1.052	189	144	132
H_1C_4	5.83	8.07	10.65	1.026	0.925	0.976	189	144	132
H_2C_2	3.98	6.20	8.15	0.824	0.739	0.729	190	145	132
H_2C_3	4.36	6.90	8.88	0.935	0.841	0.827	192	146	133
H_2C_4	4.67	7.35	9.50	0.953	0.857	0.817	198	149	136
H_3C_2	4.02	6.17	8.11	0.757	0.676	0.683	174	136	126
H_3C_3	4.32	6.67	8.73	0.868	0.780	0.768	185	142	130
H_3C_4	4.74	7.10	9.22	0.912	0.820	0.800	187	143	131
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
H_1R_1	5.00	7.80	9.81	0.941	0.841	0.893	180	139	128
H_1R_2	4.98	6.59	9.16	0.919	0.832	0.863	180	139	128
H_1R_3	6.17	8.50	11.44	1.123	1.016	1.169	184	141	130
H_2R_1	4.42	6.77	8.19	0.852	0.760	0.782	185	142	130
H_2R_2	4.00	5.87	8.17	0.811	0.730	0.717	185	142	130
H_2R_3	4.59	7.82	10.18	1.049	0.947	0.875	189	145	132
H_3R_1	4.09	6.60	8.13	0.803	0.714	0.762	177	137	127
H_3R_2	4.18	5.98	8.29	0.785	0.705	0.684	177	138	127
H_3R_3	4.80	7.37	9.64	0.950	0.855	0.805	182	140	129
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

C_2R_1	3.96	6.44	7.90	0.789	0.703	0.725	180	139	128
C_2R_2	4.06	5.62	7.86	0.742	0.666	0.668	184	142	130
C_2R_3	4.88	7.38	9.88	0.951	0.854	0.917	180	139	128
C_3R_1	4.53	7.21	8.93	0.896	0.800	0.853	186	142	131
C_3R_2	4.33	6.21	8.57	0.872	0.788	0.804	184	141	130
C_3R_3	5.23	7.89	10.50	1.091	0.988	0.990	195	148	135
C_4R_1	5.01	7.52	9.31	0.910	0.812	0.859	189	144	132
C_4R_2	4.76	6.60	9.19	0.901	0.814	0.793	187	143	131
C_4R_3	5.47	8.41	10.88	1.081	0.976	0.742	198	150	136
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_2R_1$	4.40	7.07	8.94	0.856	0.765	0.797	179	138	128
$H_1C_2R_2$	4.64	6.07	8.44	0.829	0.748	0.779	182	140	129
$H_1C_2R_3$	5.68	8.07	10.73	1.014	0.913	1.116	179	139	128
$H_1C_3R_1$	4.99	7.92	9.98	0.963	0.861	0.933	187	143	131
$H_1C_3R_2$	4.90	6.72	9.36	0.966	0.876	0.946	187	143	131
$H_1C_3R_3$	6.35	8.57	11.82	1.241	1.129	1.278	192	146	133
$H_1C_4R_1$	5.62	8.40	10.50	1.002	0.897	0.949	186	142	131
$H_1C_4R_2$	5.38	6.96	9.68	0.963	0.872	0.865	185	142	130
$H_1C_4R_3$	6.49	8.85	11.78	1.114	1.006	1.113	196	148	135
$H_2C_2R_1$	3.91	6.14	7.36	0.782	0.696	0.701	187	143	131
$H_2C_2R_2$	3.67	5.22	7.41	0.694	0.621	0.613	193	147	134
$H_2C_2R_3$	4.36	7.23	9.69	0.998	0.899	0.874	188	144	132
$H_2C_3R_1$	4.49	6.97	8.34	0.879	0.783	0.835	190	145	132
$H_2C_3R_2$	3.98	5.96	8.17	0.869	0.785	0.778	184	141	130
$H_2C_3R_3$	4.60	7.78	10.13	1.056	0.953	0.868	201	151	137
$H_2C_4R_1$	4.84	7.19	8.87	0.896	0.799	0.809	196	148	135
$H_2C_4R_2$	4.34	6.43	8.91	0.870	0.784	0.759	196	148	135
$H_2C_4R_3$	4.83	8.45	10.71	1.094	0.988	0.882	202	152	138
$H_3C_2R_1$	3.58	6.11	7.38	0.730	0.649	0.677	174	135	125
$H_3C_2R_2$	3.88	5.57	7.73	0.702	0.627	0.610	178	138	127
$H_3C_2R_3$	4.59	6.84	9.23	0.840	0.750	0.760	172	134	125
$H_3C_3R_1$	4.11	6.74	8.45	0.847	0.755	0.791	181	139	128
$H_3C_3R_2$	4.11	5.95	8.18	0.781	0.703	0.687	182	140	129
$H_3C_3R_3$	4.75	7.34	9.55	0.977	0.882	0.825	193	146	134
$H_3C_4R_1$	4.57	6.96	8.56	0.831	0.739	0.817	185	142	130
$H_3C_4R_2$	4.56	6.41	8.97	0.872	0.786	0.754	181	140	128
$H_3C_4R_3$	5.08	7.94	10.14	1.034	0.935	0.830	196	149	135
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 19. The per cent protein and soluble and insoluble carbohydrates in the shoot of the plants, received water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M of GA_3 (H_1), IAA (H_2) or IBA (H_3) through nutrient solution on 7th (R_1) or 14th (R_2) or both 7th and 14th (R_3) days, after the emergence of the seedlings. The sampling was done at 25, 35 and 45 days, after sowing.

Treatments	Protein			Sol. carbohydrate			Insol. Carbohydrate		
	DAYS AFTER SOWING								
	25	35	45	25	35	45	25	35	45
Control(C1)	**17.00**	**16.40**	**15.00**	**5.300**	**6.675**	**6.905**	**34.00**	**36.05**	**27.50**
H_1	18.90	17.70	16.40	6.714	7.974	8.810	42.21	43.24	32.96
H_2	19.50	18.20	16.95	5.770	7.363	7.605	39.44	39.96	30.98
H_3	18.47	17.30	16.05	5.499	7.037	7.369	37.32	38.35	29.74
CD at 5%	**1.22**	**1.20**	**1.15**	**0.221**	**0.276**	**0.292**	**2.27**	**1.77**	**1.41**
C_2	19.05	17.72	15.45	5.760	7.141	7.430	37.18	38.84	29.86
C_3	19.59	18.45	15.5	6.179	7.663	8.021	40.87	41.84	32.21
C_4	20.01	18.80	15.90	6.043	7.570	8.332	40.92	40.87	31.61
CD at 5%	**1.22**	**1.12**	**1.15**	**0.221**	**0.276**	**0.292**	**2.27**	**1.77**	**1.41**
R_1	18.80	17.60	16.30	5.795	6.865	7.402	39.70	41.50	31.91
R_2	18.90	17.50	16.35	5.388	6.769	7.217	34.61	36.40	27.73
R_3	19.25	18.10	16.85	6.799	8.740	9.165	44.67	43.64	34.04
CD at 5%	**1.22**	**1.12**	**1.15**	**0.221**	**0.276**	**0.292**	**2.27**	**1.77**	**1.41**
H_1C_2	17.50	16.42	15.10	6.421	7.647	8.316	39.38	41.41	31.42
H_1C_3	18.56	17.00	16.75	6.952	8.250	9.026	43.60	44.96	34.11
H_1C_4	18.35	17.30	16.90	6.769	8.024	9.088	43.66	43.36	33.34
H_2C_2	18.17	15.25	14.00	5.537	7.011	7.074	36.79	38.09	29.50
H_2C_3	18.65	17.20	16.42	5.942	7.546	7.651	40.82	41.23	32.01
H_2C_4	18.80	17.16	16.25	5.831	7.533	8.088	40.72	40.55	31.42
H_3C_2	19.07	18.05	17.65	5.322	6.767	6.901	35.37	37.02	28.65
H_3C_3	19.20	18.02	17.58	5.645	7.192	7.386	38.20	39.32	30.51
H_3C_4	17.00	16.90	15.17	5.529	7.154	7.821	38.39	38.70	30.07
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
H_1R_1	18.05	17.90	16.40	6.220	7.306	8.293	42.60	44.46	33.96
H_1R_2	17.01	16.95	15.45	6.184	7.114	8.111	36.56	38.07	29.02
H_1R_3	18.10	17.40	16.82	7.738	9.500	10.026	47.47	47.19	35.89
H_2R_1	17.95	16.50	15.68	5.714	6.773	7.101	39.39	40.83	31.50
H_2R_2	18.01	17.95	16.65	5.021	6.674	6.711	33.78	35.69	27.15
H_2R_3	19.00	18.50	17.69	6.576	8.642	9.002	45.16	43.35	34.28
H_3R_1	18.05	17.01	16.22	5.451	6.515	6.812	37.11	39.82	30.26
H_3R_2	17.07	16.10	15.91	4.960	6.520	6.830	33.49	35.44	27.01
H_3R_3	18.00	17.21	16.19	6.084	8.078	8.467	41.37	40.38	31.96
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

C_2R_1	17.90	16.32	15.30	5.444	6.438	6.683	36.28	38.81	29.85
C_2R_2	16.95	15.90	14.89	5.120	6.360	6.762	32.05	35.01	26.35
C_2R_3	18.30	17.41	16.90	6.716	8.626	8.847	43.21	42.70	33.38
C_3R_1	18.15	17.59	16.55	6.090	7.182	7.513	41.92	43.34	33.44
C_3R_2	17.00	16.89	15.90	5.524	6.881	7.295	35.33	37.65	28.33
C_3R_3	18.45	17.34	16.75	6.925	8.925	9.256	45.37	44.52	34.88
C_4R_1	18.16	17.09	16.10	5.852	6.974	8.010	40.90	42.35	32.44
C_4R_2	17.58	17.01	16.00	5.521	7.067	7.595	36.45	36.55	28.49
C_4R_3	18.10	17.05	16.22	6.757	8.670	9.392	45.42	43.71	33.90
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_2R_1$	18.00	17.03	17.33	5.820	6.866	7.515	39.04	41.75	31.89
$H_1C_2R_2$	17.10	16.95	15.43	5.831	6.759	7.709	33.81	36.51	27.69
$H_1C_2R_3$	18.22	17.25	16.54	7.612	9.314	9.722	45.28	45.96	34.68
$H_1C_3R_1$	18.35	17.37	16.62	6.497	7.518	8.335	44.27	46.25	35.25
$H_1C_3R_2$	17.85	16.93	15.00	6.355	7.284	8.357	37.40	39.35	29.81
$H_1C_3R_3$	18.70	17.00	16.05	8.002	9.949	10.387	49.12	49.28	37.27
$H_1C_4R_1$	18.60	17.67	16.65	6.344	7.535	9.028	44.49	45,39	34.74
$H_1C_4R_2$	17.95	16.85	15.70	6.366	7.298	8.267	38.47	38.34	29.57
$H_1C_4R_3$	18.05	17.00	16.00	7.598	9.238	9.968	48.02	46.33	35.72
$H_2C_2R_1$	18.90	17.80	16.85	5.392	6.360	6.409	35.98	38.23	29.46
$H_2C_2R_2$	16.90	16.00	15.00	4.720	6.120	6.109	30.43	33.57	25.19
$H_2C_2R_3$	18.55	17.85	16.72	6.500	8.553	8.705	43.96	42.47	33.86
$H_2C_3R_1$	18.01	17.55	16.00	5.981	7.099	7.180	41.72	42.41	33.00
$H_2C_3R_2$	17.21	16.25	15.45	5.185	6.805	6.628	35.27	37.58	28.18
$H_2C_3R_3$	18.45	17.35	16.32	6.660	8.733	8.946	45.46	43.71	34.84
$H_2C_4R_1$	18.23	17.32	16.41	5.769	6.860	7.713	40.46	41.84	32.04
$H_2C_4R_2$	17.12	16.21	15.12	5.157	7.098	7.195	35.65	35.93	28.08
$H_2C_4R_3$	17.00	16.35	15.43	6.568	8.641	9.356	46.05	43.88	34.14
$H_3C_2R_1$	18.00	17.43	16.93	5.121	6.090	6.125	33.81	36.46	28.19
$H_3C_2R_2$	17.85	16.86	15.54	4.808	6.200	6.466	31.90	34.95	26.18
$H_3C_2R_3$	18.77	17.67	17.75	6.037	8.010	8.113	40.39	39.66	31.59
$H_3C_3R_1$	17.94	16.89	15.90	5.791	6.928	7.022	39.76	41.37	32.05
$H_3C_3R_2$	16.55	15.39	14.00	5.033	6.555	6.700	33.32	36.01	27.00
$H_3C_3R_3$	18.01	17.44	16.40	6.111	8.092	8.436	41.52	40.87	32.48
$H_3C_4R_1$	18.50	17.34	16.68	5.442	6.526	7.288	37.76	39.83	30.54
$H_3C_4R_2$	17.95	16.99	15.88	5.040	6.805	7.323	35.24	35.36	27.83
$H_3C_4R_3$	18.10	17.00	16.78	6.104	8.130	8.851	42.18	40.90	31.83
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 20. The per cent nitrogen, phosphorus and potassium in the shoots of the plants, received water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M of GA_3 (H_1), IAA (H_2) or IBA (H_3) through nutrient solution on 7th (R_1) or 14th (R_2) or both 7th and 14th (R_3) days, after the emergence of the seedlings. The sampling was done at 25, 35 and 45 days, after the sowing.

Treatments	Nitrogen			Phosphorus			Potassium		
	DAYS AFTER SOWING								
	25	35	45	25	35	45	25	35	45
Control (C_1)	**3.30**	**3.10**	**2.80**	**0.415**	**0.390**	**0.372**	**2.65**	**2.50**	**2.30**
H_1	3.94	3.64	3.40	0.493	0.459	0.432	3.18	2.97	2.79
H_2	3.79	3.51	3.29	0.474	0.442	0.417	3.06	2.85	2.69
H_3	3.58	3.31	3.09	0.448	0.417	0.392	2.89	2.70	2.53
CD at 5%	**0.198**	**0.181**	**0.188**	**0.024**	**0.021**	**0.022**	**0.159**	**0.144**	**0.148**
C_2	3.51	3.25	3.03	0.440	0.410	0.385	2.84	2.65	2.49
C_3	3.82	3.53	3.31	0.478	0.446	0.419	3.09	2.88	2.71
C_4	3.97	3.67	3.45	0.496	0.462	0.437	3.21	2.99	2.82
CD at 5%	**0.198**	**0.181**	**0.188**	**0.024**	**0.021**	**0.022**	**0.159**	**0.144**	**0.148**
R_1	3.89	3.60	3.37	0.487	0.454	0.427	3.15	2.93	2.76
R_2	3.38	3.12	2.94	0.422	0.393	0.372	2.73	2.54	2.40
R_3	4.03	3.73	3.48	0.505	0.471	0.442	3.26	3.04	2.86
CD at 5%	**0.198**	**0.181**	**0.188**	**0.024**	**0.021**	**0.022**	**0.159**	**0.144**	**0.148**
H_1C_2	3.78	3.49	3.28	0.472	0.440	0.416	3.05	2.84	2.68
H_1C_3	3.97	3.67	3.42	0.497	0.464	0.435	3.21	3.00	2.81
H_1C_4	4.06	3.76	3.51	0.508	0.474	0.445	3.29	3.06	2.88
H_2C_2	3.43	3.17	2.94	0.430	0.401	0.375	2.78	2.59	2.42
H_2C_3	3.83	3.54	3.31	0.479	0.446	0.420	3.09	2.88	2.71
H_2C_4	4.12	3.81	3.61	0.514	0.478	0.455	3.32	3.09	2.94
H_3C_2	3.33	3.08	2.86	0.418	0.389	0.364	2.70	2.51	2.35
H_3C_3	3.67	3.39	3.18	0.459	0.428	0.403	2.97	2.76	2.61
H_3C_4	3.73	3.45	3.23	0.467	0.435	0.409	3.02	2.81	2.64
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
H_1R_1	4.16	3.84	3.60	0.520	0.484	0.456	3.36	3.13	2.95
H_1R_2	3.48	3.22	3.02	0.436	0.406	0.383	2.81	2.62	2.47
H_1R_3	4.17	3.86	3.59	0.523	0.487	0.456	3.38	3.15	2.95
H_2R_1	3.19	3.61	3.39	0.489	0.455	0.429	3.16	2.94	2.77
H_2R_2	3.34	3.09	2.90	0.418	0.489	0.368	2.70	2.51	2.37
H_2R_3	4.13	3.82	3.58	0.516	0.481	0.453	3.34	3.11	2.93
H_3R_1	3.62	3.35	3.11	0.454	0.423	0.396	2.93	2.73	2.56
H_3R_2	3.31	3.06	2.88	0.414	0.385	0.364	2.67	2.49	2.35
H_3R_3	3.80	3.52	3.29	0.476	0.444	0.417	3.08	2.87	2.69
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

C_2R_1	3.59	3.32	3.10	0.449	0.419	0.394	2.90	2.70	2.54
C_2R_2	3.12	2.88	2.70	0.390	0.364	0.342	2.52	2.35	2.21
C_2R_3	3.83	3.54	3.29	0.480	0.448	0.419	3.10	2.89	2.71
C_3R_1	3.96	3.66	3.41	0.496	0.448	0.434	3.21	2.99	2.80
C_3R_2	3.43	3.17	2.98	0.428	0.399	0.377	2.77	2.58	2.44
C_3R_3	4.08	3.77	3.53	0.511	0.476	0.448	3.30	3.07	2.89
C_4R_1	4.13	3.82	3.58	0.517	0.481	0.454	3.34	3.11	2.93
C_4R_2	3.59	3.32	3.13	0.448	0.417	0.395	2.90	2.69	2.55
C_4R_3	4.19	3.88	3.63	0.524	0.488	0.461	3.39	3.15	2.98
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_2R_1$	3.92	3.63	3.42	0.490	0.456	0.432	3.17	2.95	2.79
$H_1C_2R_2$	3.30	3.05	2.87	0.413	0.384	0.364	2.67	2.48	2.35
$H_1C_2R_3$	4.11	3.80	3.56	0.514	0.478	0.451	3.32	3.09	2.91
$H_1C_3R_1$	4.05	3.75	3.47	0.509	0.474	0.442	3.29	3.07	2.86
$H_1C_3R_2$	3.64	3.36	3.18	0.454	0.422	0.401	2.93	2.73	2.59
$H_1C_3R_3$	4.22	3.91	3.62	0.530	0.494	0.461	3.42	3.19	2.91
$H_1C_4R_1$	4.49	4.15	3.91	0.561	0.522	0.495	3.63	3.37	2.20
$H_1C_4R_2$	3.51	3.25	3.02	0.440	0.410	0.384	2.84	2.65	2.48
$H_1C_4R_3$	4.18	3.87	3.59	0.524	0.489	0.457	3.39	3.16	2.95
$H_2C_2R_1$	3.54	3.28	3.06	0.444	0.414	0.389	2.87	2.67	2.51
$H_2C_2R_2$	2.89	3.68	2.48	0.364	0.339	0.316	2.35	2.19	2.04
$H_2C_2R_3$	3.84	3.56	3.29	0.482	0.450	0.420	3.12	2.91	2.71
$H_2C_3R_1$	3.92	3.63	3.38	0.492	0.458	0.430	3.18	2.96	2.78
$H_2C_3R_2$	3.46	3.20	3.02	0.433	0.403	0.382	2.79	2.60	2.47
$H_2C_3R_3$	4.06	3.78	3.54	0.512	0.477	0.449	3.31	3.08	2.90
$H_2C_4R_1$	4.25	3.93	3.72	0.530	0.493	0.470	3.43	3.19	3.03
$H_2C_4R_2$	3.66	3.38	3.21	0.457	0.425	0.405	2.95	2.74	2.61
$H_2C_4R_3$	4.45	4.11	3.90	0.555	0.516	0.492	3.59	3.33	3.18
$H_3C_2R_1$	3.30	3.05	2.83	0.414	0.386	0.360	2.67	2.49	2.33
$H_3C_2R_2$	3.16	2.92	2.74	0.394	0.367	0.347	2.55	2.37	2.24
$H_3C_2R_3$	3.53	3.27	3.02	0.445	0.415	0.386	2.87	2.68	2.49
$H_3C_3R_1$	3.91	3.61	3.39	0.489	0.455	0.429	3.16	2.94	2.77
$H_3C_3R_2$	3.18	2.94	2.74	0.398	0.371	0.349	2.57	2.40	2.25
$H_3C_3R_3$	3.93	3.63	3.42	0.491	0.457	0.433	3.17	2.95	2.80
$H_3C_4R_1$	3.65	3.38	3.11	0.459	0.428	0.398	2.96	2.76	2.57
$H_3C_4R_2$	3.60	3.32	3.15	0.448	0.417	0.397	2.90	2.48	2.57
$H_3C_4R_3$	3.94	3.65	3.42	0.494	0.460	0.433	3.19	3.09	2.80
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

4.4 Experiment 4

Surface sterilized seeds of pea were soaked in 50 cm^3 of water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M aqueous solution of GA_3 (H_1), IAA (H_2) or IBA (H_3) for 12 (S_1) or 18 (S_2) hours. These pre-treated seeds were sown in pots of 9 inch diameter, lined on their inner surface with polythene sleeves, filled with acid washed sand. Additional quantity (50 cm^3) of the same concentrations of each hormone was also supplied to the respective pots either on day 7 (R_1) or 14(R_2) or both, i.e. 7 and 14 (R_3), after the emergence of the seedlings, with the nutrient solution as in Experiment 3. The plants were sampled and analysed at the same intervals, as in Experiment 2. The data has been summarized in tables 21 to 28 and is described, in short, in the following pages:

4.4.1 Root length per plant

The treated plants possessed significantly longer roots than the control (Table 21). IAA (H_2) proved to be superior than the other hormones. The root length increased with an increase in the hormone concentration. Comparable and significantly higher values were recorded, at the two higher concentrations (C_3 and C_4) of the hormones. Although, two soaking periods (S_1 and S_2) did not differ significantly in their effect but the application of the hormones twice (R_3) was far superior than once (R_1 or R_2), at all the stages of growth.

Considering the interaction effect, between various factors, the significance is observed mostly, at 35 DAS. The most effective combination is H_2 C_3 R_3 (i.e., pre-treatment of seeds with 10^{-7}M of IAA and fed twice to the seedlings).

4.4.2 Root fresh weight per plant

The treatment significantly increased the root fresh weight and the pattern of response was comparable with that of the root length (Table 21). It increased with the age of the plant and gave maximum response to IAA (H_2) which was followed by IBA(H_3) and GA_3 (H_1), at 25 and 45 DAS. An increase in the hormone concentration (i.e., 10^{-9}, 10^{-7} and 10^{-5} M) induced a linear increase, in the root fresh weight. However, the effect of the two higher concentrations (C_3 and C_4) was at par, at all the stages of growth. The response of soaking durations was non-significant. The hormonal application twice (R_3) was again significantly superior, at the two earlier stages of growth (25 and 35 DAS) but was at par with R_2, at the last sampling (45 DAS).

The various factors interacted significantly. The best possible combinations are H_2C_3, H_2S_1, H_2S_2, H_3R_3, C_4S_2, C_4R_3, C_4S_2, C_4R_3 and S_2R_3; $H_3C_4S_2$, $H_2C_3R_2$, $H_2S_2R_2$, $C_3S_2R_2$, $C_3S_2R_3$, $C_4S_2R_3$, $C_2S_2R_3$ and $H_1C_3S_1R_3$; $H_2C_3S_1R_3$ and $H_2C_3S_2R_2$. In short, it may be derived that IAA at a concentrations of 10^{-7} or 10^{-9} M, for treating the seeds and feeding the seedlings twice, proved best.

4.4.3 Root dry weight per plant

The treatment significantly improved root dry weight and the effect was comparable with that of root fresh weight (Table 21). A maximum response was generated by the two higher concentrations (C_3 and C_4) of the IAA (H_2) which were at par in their effect, at the later stage of growth (i.e., 45 DAS). The hormonal application twice (R_3) proved significantly superior than single applications (R_1 or R_2).

Table 21. The length (cm), fresh and dry weight (g) of the root, received water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M of GA_3 (H_1), IAA (H_2) or IBA (H_3) through seeds for 12 (S_1) or 18 (S_2) hours and with nutrient solution on 7th (R_1) or 14th (R_2) or both 7th and 14th (R_3) days, after the emergence of the seedlings. The sampling was done at 25, 35 and 45 days, after sowing.

Treatments	Length			Fresh weight			Dry weight		
	DAYS AFTER SOWING								
	25	35	45	25	35	45	25	35	45
H_1	14.17	24.36	29.64	0.285	0.398	0.453	1.077	1.530	1.863
H_2	16.62	27.04	33.59	0.315	0.420	0.475	1.204	1.624	2.020
H_3	14.62	21.70	27.93	0.251	0.340	0.473	1.105	1.526	1.791
CD at 5%	**0.41**	**0.28**	**0.81**	**0.003**	**0.006**	**0.037**	**0.039**	**0.055**	**0.051**
C_1	11.96	19.38	24.11	0.221	0.308	0.369	0.828	1.237	1.475
C_2	14.53	23.49	29.23	0.269	0.369	0.441	1.036	1.474	1.793
C_3	16.43	26.21	32.80	0.315	0.427	0.491	1.215	1.6612	2.055
C_4	16.623	26.39	32.39	0.330	0.450	0.463	1.235	1.671	2.042
CD at 5%	**0.47**	**0.32**	**0.93**	**0.003**	**0.007**	**0.043**	**0.045**	**0.063**	**0.058**
S_1	15.10	24.35	30.25	0.281	0.388	0.446	1.065	1.498	1.831
S_2	15.17	24.38	30.42	0.286	0.390	0.481	1.193	1.623	1.952
CD at 5%	**NS.**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
R_1	15.01	24.25	30.19	0.276	0.384	0.438	1.036	1.471	1.791
R_2	14.70	23.61	29.47	0.276	0.379	0.462	1.140	1.559	1.927
R_3	15.70	25.24	31.50	0.300	0.404	0.640	1.211	1.652	1.956
CD at 5%	**0.41**	**0.28**	**0.81**	**0.003**	**0.006**	**0.037**	**0.039**	**0.055**	**0.051**
H_1C_1	12.45	19.69	24.72	0.220	0.308	0.371	0.825	1.244	1.478
H_1C_2	13.79	23.55	28.73	0.266	0.382	0.448	1.014	1.508	1.802
H_1C_3	14.812	25.96	31.36	0.317	0.437	0.494	1.232	1.684	2.083
H_1C_4	14.63	26.24	30.75	0.317	0.434	0.497	1.136	1.489	1.889
H_2C_1	11.79	19.59	24.15	0.220	0.309	0.372	0.841	1.250	1.493
H_2C_2	15.80	25.83	32.02	0.303	0.402	0.467	1.196	1.588	1.988
H_2C_3	18.59	29.97	37.35	0.359	0.487	0.527	1.406	1.836	2.315
H_2C_4	19.31	30.76	37.82	0.360	0.486	0.532	1.174	1.623	1.084
H_3C_1	11.65	18.87	23.48	0.223	0.308	0.364	0.820	1.217	1.455
H_3C_2	14.01	21.03	26.95	0.240	0.323	0.408	0.899	1.325	1.589
H_3C_3	15.89	22.71	29.69	0.267	0.359	0.452	1.008	1.464	1.765
H_3C_4	15.92	22.17	28.61	0.254	0.340	0.448	1.395	1.900	2.154
CD at 5%	**0.81**	**0.57**	**1.62**	**0.006**	**0.013**	**0.075**	**0.078**	**0.109**	**0.101**
H_1S_1	14.10	24.26	29.51	0.281	0.398	0.448	1.067	1.519	1.848
H_1S_2	14.24	24.46	29.77	0.289	0.390	0.457	1.056	1.544	1.878
H_2S_1	16.52	26.90	33.40	0.345	0.424	0.468	1.203	1.611	2.010
H_2S_2	16.73	27.18	33.70	0.316	0.433	0.481	1.205	1.631	2.030
H_3S_1	14.58	21.89	28.13	0.248	0.340	0.421	0.924	1.364	1.634
H_3S_2	14.55	21.50	27.73	0.254	0.340	0.416	1.287	1.689	1.947
CD at 5%	**NS**	**0.40**	**NS**	**0.004**	**NS**	**0.053**	**0.055**	**0.077**	**0.072**

H_1R_1	14.05	24.22	29.43	0.274	0.390	0.439	1.033	1.481	1.799
H_1R_2	13.87	23.64	28.85	0.275	0.381	0.464	1.036	1.586	1.966
H_1R_3	14.61	25.21	30.63	0.306	0.417	0.455	1.031	1.524	1.825
H_2R_1	16.45	26.81	33.28	0.308	0.429	0.462	1.159	1.571	1.952
H_2R_2	15.95	25.95	32.22	0.305	0.413	0.499	1.205	1.699	2.131
H_2R_3	17.47	28.36	35.26	0.334	0.445	0.463	1.168	1.601	1.978
H_3R_1	14.53	21.71	27.88	0.245	0.332	0.415	0.916	1.351	1.627
H_3R_2	14.28	21.23	27.32	0.248	0.330	0.423	0.918	1.392	1.685
H_3R_3	15.55	22.15	28.60	0.260	0.351	0.456	1.433	1.833	2.065
CD at 5%	**0.12**	**0.11**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
C_1S_1	11.89	19.31	23.18	0.220	0.308	0.356	0.798	1.198	1.425
C_1S_2	12.03	19.46	24.22	0.222	0.309	0.382	0.859	1.277	1.526
C_2S_1	14.67	23.86	27.96	0.266	0.369	0.430	0.992	1.429	1.729
C_2S_2	14.40	23.08	28.83	0.272	0.369	0.453	1.081	1.519	1.857
C_3S_1	16.28	25.96	27.44	0.312	0.423	0.480	1.209	1.622	2.022
C_3S_2	16.58	26.47	33.12	0.317	0.432	0.502	1.222	1.700	2.087
C_4S_1	16.56	26.27	31.64	0.306	0.420	0.518	1.061	1.544	1.947
C_4S_2	16.86	26.51	32.53	0.315	0.421	0.548	1.409	1.797	2.138
CD at 5%	**NS**	**0.46**	**NS**	**NS**	**NS**	**NS**	**0.064**	**0.089**	**NS**
C_1R_1	11.92	19.43	24.12	0.220	0.309	0.358	0.810	1.202	1.437
C_1R_2	11.88	19.32	24.00	0.223	0.310	0.359	0.792	1.198	1.422
C_1R_3	12.08	19.40	24.23	0.219	0.306	0.390	0.882	1.312	1.567
C_2R_1	14.58	23.78	29.51	0.258	0.360	0.411	0.993	1.354	1.676
C_2R_2	13.57	21.64	27.08	0.266	0.342	0.452	1.073	1.543	1.868
C_2R_3	15.46	24.95	31.11	0.284	0.405	0.461	1.045	1.524	1.835
C_3R_1	16.02	25.54	31.96	0.304	0.417	0.458	1.133	1.567	1.929
C_3R_2	15.57	24.83	31.07	0.298	0.412	0.518	1.317	1.748	2.189
C_3R_3	17.71	28.27	35.37	0.341	0.453	0.496	1.197	1.668	2.046
C_4R_1	16.52	26.23	32.19	0.300	0.419	0.527	1.008	1.560	1.920
C_4R_2	16.79	26.64	32.71	0.296	0.431	0.519	1.177	1.545	2.030
C_4R_3	0.335	0.431	0.522	1.520	1.907	2.176	16.56	26.30	32.28
CD at 5%	**0.82**	**0.57**	**1.63**	**0.006**	**0.013**	**0.045**	**0.078**	**0.109**	**0.101**
S_1R_1	15.09	24.37	30.65	0.274	0.385	0.433	1.017	1.451	1.764
S_1R_2	14.53	23.37	29.16	0.271	0.374	0.461	1.014	1.556	1.922
S_1R_3	15.68	25.31	31.53	0.229	0.403	0.443	1.043	1.486	1.807
S_2R_1	14.93	24.12	30.04	0.278	0.382	0.444	1.055	1.493	1.817
S_2R_2	14.87	23.84	29.77	0.280	0.380	0.463	1.045	1.561	1.933
S_2R_3	15.22	25.18	31.46	0.301	0.404	0.836	1.379	1.819	2.105
CD at 5%	**NS**	**0.40**	**NS**	**NS**	**NS**	**NS**	**0.055**	**0.077**	**0.072**
$H_1C_1S_1$	12.44	19.66	24.69	0.219	0.308	0.357	0.799	1.198	1.426
$H_1C_1S_2$	12.46	19.71	24.75	0.221	0.309	0.384	0.851	1.291	1.530
$H_1C_2S_1$	13.75	23.70	28.81	0.266	0.384	0.433	0.973	1.464	1.740
$H_1C_2S_2$	13.84	23.41	28.65	0.265	0.380	0.463	1.055	1.553	1.863
$H_1C_3S_1$	14.69	25.71	31.08	0.314	0.433	0.485	1.245	1.647	2.066
$H_1C_3S_2$	14.93	26.20	31.64	0.320	0.441	0.503	1.219	1.721	2.100

$H_1C_4S_1$	14.51	26.97	32.45	0.303	0.436	0.486	1.232	1.749	2.138
$H_1C_4S_2$	14.75	27.51	33.05	0.330	0.432	0.448	1.189	1.588	2.000
$H_2C_1S_1$	11.79	19.56	24.12	0.220	0.308	0.355	0.771	1.194	1.404
$H_2C_1S_2$	11.79	19.63	24.17	0.221	0.309	0.389	0.911	1.306	1.583
$H_2C_2S_1$	15.66	25.74	31.84	0.297	0.395	0.450	1.122	1.524	1.889
$H_2C_2S_2$	15.94	25.91	32.20	0.309	0.410	0.484	1.271	1.652	2.087
$H_2C_3S_1$	18.37	29.62	36.92	0.361	0.479	0.507	1.408	1.779	2.277
$H_2C_3S_2$	18.80	30.32	37.79	0.357	0.494	0.547	1.404	1.892	1.354
$H_2C_4S_1$	19.27	30.67	37.22	0.363	0.485	0.561	1.313	1.746	2.271
$H_2C_4S_2$	19.36	30.85	37.93	0.357	0.487	0.503	1.035	1.500	1.897
$H_3C_1S_1$	11.45	18.71	23.20	0.222	0.308	0.357	0.822	1.201	1.445
$H_3C_1S_2$	11.84	19.03	23.75	0.223	0.309	0.371	0.817	1.233	1.464
$H_3C_2S_1$	14.61	22.15	28.28	0.236	0.329	0.405	0.881	1.299	1.557
$H_3C_2S_2$	13.41	19.91	25.63	0.244	0.317	0.411	0.918	1.351	1.621
$H_3C_3S_1$	15.77	22.53	29.46	0.262	0.357	0.446	0.974	1.440	1.723
$H_3C_3S_2$	16.02	22.88	29.92	0.273	0.361	0.457	1.043	1.488	1.807
$H_3C_4S_1$	15.92	22.16	28.59	0.252	0.338	0.476	0.817	1.318	1.611
$H_3C_4S_2$	15.93	22.18	28.62	0.256	0.343	0.483	2.173	2.482	2.697
CD at 5%	**NS**	**NS**	**NS**	**0.009**	**NS**	**0.106**	**0.110**	**0.154**	**0.143**
$H_1C_1R_1$	12.41	19.55	24.54	0.221	0.307	0.361	0.798	1.217	1.439
$H_1C_1R_2$	12.71	20.07	25.21	0.220	0.315	0.359	0.791	1.190	1.415
$H_1C_1R_3$	12.30	19.43	24.41	0.219	0.302	0.393	0.887	1.326	1.581
$H_1C_2R_1$	13.68	23.71	28.75	0.251	0.375	0.414	0.965	1.375	1.671
$H_1C_2R_2$	13.33	21.97	27.15	0.259	0.350	0.457	1.083	1.583	1.904
$H_1C_2R_3$	14.38	24.98	30.28	0.287	0.422	0.473	0.994	1.567	1.829
$H_1C_3R_1$	14.55	25.48	30.79	0.304	0.422	0.453	1.152	1.567	1.942
$H_1C_3R_2$	13.81	24.25	29.28	0.305	0.414	0.518	1.334	1.784	2.228
$H_1C_3R_3$	16.07	28.14	34.00	0.345	0.474	0.508	1.211	1.701	2.079
$H_1C_4R_1$	14.57	26.16	30.64	0.298	0.428	0.531	1.117	1.581	1.941
$H_1C_4R_2$	14.64	26.26	30.77	0.298	0.436	0.540	1.256	1.586	2.116
$H_1C_4R_3$	14.68	26.30	30.83	0.354	0.438	0.445	0.833	1.300	1.609
$H_2C_1R_1$	12.03	20.01	24.64	0.219	0.319	0.353	0.808	1.176	1.418
$H_2C_1R_2$	11.44	19.00	23.42	0.219	0.300	0.368	0.791	1.216	1.434
$H_2C_1R_3$	11.97	19.77	24.38	0.223	0.307	0.395	0.923	1.358	1.629
$H_2C_2R_1$	15.87	26.09	32.28	0.287	0.402	0.432	1.095	1.441	1.812
$H_2C_2R_2$	14.40	23.50	29.19	0.290	0.369	0.489	1.278	1.666	2.103
$H_2C_2R_3$	17.13	27.85	34.60	0.332	0.436	0.480	1.216	1.655	2.051
$H_2C_3R_1$	17.81	28.72	35.80	0.352	0.478	0.488	1.284	1.712	2.140
$H_2C_3R_2$	17.41	28.12	35.02	0.334	0.464	0.575	1.529	1.968	2.498
$H_2C_3R_3$	20.54	33.07	41.24	0.390	0.519	0.520	1.405	1.826	2.308
$H_2C_4R_1$	19.10	30.43	27.39	0.354	0.488	0.575	1.250	1.762	2.237
$H_2C_4R_2$	19.53	31.11	37.27	0.350	0.485	0.565	1.342	1.745	2.291
$H_2C_4R_3$	19.31	30.75	37.81	0.374	0.486	0.456	0.930	1.367	1.723
$H_3C_1R_1$	11.39	18.74	23.17	0.221	0.302	0.360	0.825	1.212	1.455

$H_3C_1R_2$	11.50	18.88	23.37	0.227	0.314	0.351	0.798	1.189	1.419
$H_3C_1R_2$	12.05	19.00	23.89	0.220	0.310	0.381	0.836	1.251	1.490
$H_3C_2R_1$	14.18	21.55	27.49	0.237	0.303	0.385	0.918	1.26	1.546
$H_3C_2R_2$	12.98	19.40	24.91	0.248	0.307	0.410	0.854	1.381	1.597
$H_3C_2R_3$	14.86	22.15	28.46	0.235	0.358	0.429	0.925	1.349	1.624
$H_3C_3R_1$	15.59	22.41	29.31	0.256	0.351	0.431	0.963	1.421	1.703
$H_3C_3R_2$	15.48	22.11	28.91	0.259	0.359	0.463	1.087	1.493	1.842
$H_3C_3R_3$	16.52	23.60	30.86	0.288	0.366	0.461	0.975	1.477	1.751
$H_3C_4R_1$	15.88	22.12	28.54	0.247	0.341	0.483	0.756	1.338	1.581
$H_3C_4R_2$	16.18	22.54	29.09	0.237	0.342	0.468	0.931	1.305	1.683
$H_3C_4R_3$	15.70	21.85	28.19	0.278	0.338	0.474	0.798	1.257	1.697
CD at 5%	**NS**	**0.98**	**NS**	**NS**	**NS**	**NS**	**0.135**	**0.180**	**0.175**
$H_1S_1R_1$	14.12	24.36	29.60	0.270	0.380	0.434	1.135	1.467	1.766
$H_1S_1R_2$	13.66	23.27	28.41	0.269	0.381	0.461	1.155	1.584	1.957
$H_1S_1R_3$	14.52	25.15	30.51	0.304	0.419	0.449	1.042	1.590	1.821
$H_1S_2R_1$	13.95	24.09	29.26	0.277	0.387	0.443	1.041	1.503	1.831
$H_1S_2R_2$	14.08	24.01	29.30	0.282	0.391	0.468	1.177	1.588	1.975
$H_1S_2R_3$	13.70	25.25	30.75	0.309	0.414	0.460	1.020	1.591	1.829
$H_2S_1R_1$	16.53	26.93	33.43	0.309	0.426	0.455	1.158	1.550	1.934
$H_2S_1R_2$	15.72	25.61	31.79	0.304	0.406	0.494	1.280	1.608	2.116
$H_2S_1R_3$	17.32	28.14	34.97	0.333	0.440	0.457	1.172	1.600	1.980
$H_2S_2R_1$	16.37	26.68	33.12	0.307	0.432	0.469	1.161	1.596	1.969
$H_2S_2R_2$	16.18	26.28	32.66	0.305	0.418	0.505	1.290	1.702	2.146
$H_2S_2R_3$	17.63	28.57	35.54	0.335	0.445	0.469	1.165	1.601	1.976
$H_3S_1R_1$	14.61	21.82	28.02	0.243	0.337	0.410	0.888	1.330	1.590
$H_3S_1R_2$	14.22	21.23	27.27	0.241	0.332	0.429	0.896	1.403	1.692
$H_3S_1R_3$	15.22	22.60	29.11	0.260	0.350	0.424	0.916	1.352	1.620
$H_3S_2R_1$	14.46	21.59	27.73	0.248	0.327	0.420	0.943	1.370	1.652
$H_3S_2R_2$	14.34	21.24	27.37	0.254	0.342	0.419	0.929	1.3812	1.678
$H_3S_2R_3$	14.84	21.68	28.09	0.260	0.351	0.428	0.950	1.315	1.714
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.095**	**0.134**	**0.124**
$C_1S_1R_1$	11.97	19.51	24.22	0.220	0.308	0.355	0.803	1.194	1.426
$C_1S_1R_2$	11.24	19.08	23.71	0.222	0.308	0.362	0.793	1.207	1.428
$C_1S_1R_3$	11.97	19.35	24.09	0.219	0.309	0.352	0.797	1.192	1.421
$C_1S_2R_1$	11.87	19.35	24.01	0.220	0.311	0.361	0.818	1.210	1.448
$C_1S_2R_2$	12.02	19.56	24.29	0.225	0.311	0.357	0.794	1.190	1.417
$C_1S_2R_3$	12.21	19.46	24.36	0.219	0.304	0.427	0.967	1.431	1.713
$C_2S_1R_1$	14.64	23.88	29.63	0.260	0.367	0.405	0.951	1.336	1.634
$C_2S_1R_2$	13.77	22.15	27.63	0.256	0.338	0.448	1.069	1.531	1.857
$C_2S_1R_3$	15.61	25.56	31.67	0.283	0.402	0.436	0.955	1.419	1.696
$C_2S_2R_1$	14.51	23.69	29.38	0.257	0.352	0.417	1.035	1.372	1.719
$C_2S_2R_2$	13.38	21.13	26.54	0.275	0.346	0.456	1.075	1.556	1.879
$C_2S_2R_3$	15.20	24.42	30.55	0.285	0.408	0.485	1.134	1.628	1.973
$C_3S_1R_1$	16.21	25.96	32.36	0.299	0.419	0.449	1.130	1.529	1.899
$C_3S_1R_2$	15.03	23.96	29.99	0.298	0.400	0.518	1.317	1.741	2.184

$C_3S_1R_3$	17.58	28.05	35.10	0.341	0.450	0.472	1.181	1.596	1.983
$C_3S_2R_1$	15.82	25.21	31.56	0.310	0.415	0.467	1.137	1.605	1.958
$C_3S_2R_2$	16.10	25.70	32.15	0.299	0.424	0.519	1.317	1.755	2.194
$C_3S_2R_3$	17.83	26.48	32.63	0.341	0.456	0.521	1.212	1.740	2.109
$C_4S_1R_1$	16.52	26.23	32.19	0.297	0.416	0.522	0.985	1.549	1.896
$C_4S_1R_2$	16.60	26.30	32.31	0.290	0.420	0.517	1.158	1.547	2.018
$C_4S_1R_3$	16.57	26.27	32.26	0.331	0.423	0.514	1.040	1.538	1.927
$C_4S_2R_1$	16.51	26.23	32.18	0.303	0.421	0.531	1.031	1.571	1.944
$C_4S_2R_2$	16.92	26.97	32.11	0.301	0.423	0.521	1.196	1.544	2.043
$C_4S_2R_3$	16.53	26.33	32.30	0.339	0.418	0.530	1.001	1.776	2.426
CD at 5%	**NS**	**0.805**	**NS**	**0.009**	**NS**	**0.036**	**0.110**	**0.154**	**NS**
$H_1C_1S_1R_1$	12.33	19.53	24.50	0.218	0.306	0.367	0.830	1.225	1.468
$H_1C_1S_1R_2$	12.78	20.17	25.34	0.228	0.314	0.356	0.758	1.287	1.389
$H_1C_1S_1R_3$	12.22	19.29	24.23	0.211	0.303	0.345	0.810	1.181	1.422
$H_1C_1S_2R_1$	12.36	19.58	24.57	0.223	0.307	0.354	0.765	1.208	1.409
$H_1C_1S_2R_2$	12.63	19.97	25.08	0.213	0.317	0.362	0.824	1.194	1.441
$H_1C_1S_2R_3$	12.39	19.58	24.59	0.226	0.302	0.437	0.965	1.472	1.740
$H_1C_2S_1R_1$	13.71	23.77	28.62	0.259	0.381	0.403	0.913	1.346	1.614
$H_1C_2S_1R_2$	13.19	21.90	26.99	0.247	0.345	0.455	1.109	1.587	1.926
$H_1C_2S_1R_3$	14.36	25.43	30.61	0.293	0.426	0.441	0.896	1.457	1.681
$H_1C_2S_2R_1$	13.64	23.65	28.68	0.243	0.369	0.426	1.016	1.404	1.729
$H_1C_2S_2R_2$	13.46	22.05	27.32	0.221	0.354	0.459	1.057	1.578	1.883
$H_1C_2S_2R_3$	14.40	24.52	29.94	0.281	0.418	0.505	1.092	1.678	1.978
$H_1C_3S_1R_1$	14.83	25.96	31.38	0.289	0.427	0.446	1.168	1.529	1.926
$H_1C_3S_1R_2$	13.25	23.21	28.05	0.306	0.403	0.524	1.346	1.787	2.238
$H_1C_3S_1R_3$	15.50	27.97	33.82	0.348	0.469	0.485	1.223	1.624	2.033
$H_1C_3S_2R_1$	14.27	24.99	30.20	0.319	0.418	0.466	1.137	1.606	1.959
$H_1C_3S_2R_2$	14.38	25.29	30.51	0.299	0.426	0.511	1.322	1.781	2.217
$H_1C_3S_2R_3$	16.14	28.31	34.19	0.342	0.478	0.530	1.198	1.777	2.125
$H_1C_4S_1R_1$	14.60	26.19	30.69	0.294	0.427	0.518	0.909	1.568	1.855
$H_1C_4S_1R_2$	14.44	26.81	30.27	0.273	0.434	0.508	1.208	1.574	2.073
$H_1C_4S_1R_3$	14.50	26.91	30.40	0.342	0.484	0.522	1.040	1.565	1.947
$H_1C_4S_2R_1$	14.53	26.13	30.59	0.304	0.428	0.527	1.126	1.593	2.028
$H_1C_4S_2R_2$	14.85	26.72	31.28	0.325	0.449	0.540	1.305	1.599	2.159
$H_1C_4S_2R_3$	14.86	26.69	31.27	0.365	0.429	0.367	0.627	1.034	1.272
$H_2C_1S_1R_1$	15.25	20.37	25.09	0.227	0.318	0.347	0.772	1.165	1.383
$H_2C_1S_1R_2$	11.24	18.65	22.99	0.214	0.300	0.373	0.786	1.223	1.434
$H_2C_1S_1R_3$	11.89	19.67	24.29	0.218	0.306	0.345	0.755	1.195	1.393
$H_2C_1S_2R_1$	11.80	19.66	24.20	0.210	0.319	0.359	0.844	1.188	1.452
$H_2C_1S_2R_2$	11.64	19.36	23.84	0.231	0.301	0.364	0.796	1.210	1.433
$H_2C_1S_2R_3$	11.95	19.87	24.48	0.220	0.308	0.445	1.092	1.521	1.866
$H_2C_2S_1R_1$	15.75	25.90	32.03	0.289	0.400	0.427	1.051	1.407	1.755
$H_2C_2S_1R_2$	14.32	23.62	29.19	0.279	0.354	0.470	1.240	1.621	2.044
$H_2C_2S_1R_3$	16.91	27.69	34.31	0.323	0.430	0.454	1.075	1.542	1.869

$H_2C_2S_2R_1$	15.99	26.28	32.52	0.285	0.403	0.437	1.140	1.476	1.869
$H_2C_2S_2R_2$	14.46	23.46	29.19	0.300	0.383	0.508	1.315	1.711	2.162
$H_2C_2S_2R_3$	17.35	28.00	34.89	0.341	0.442	0.507	1.357	1.768	2.232
$H_2C_3S_1R_1$	18.07	29.16	36.33	0.350	0.475	0.478	1.312	1.669	2.129
$H_2C_3S_1R_2$	16.86	27.23	33.91	0.340	0.449	0.563	1.539	1.940	2.485
$H_2C_3S_1R_3$	20.17	32.48	40.50	0.393	0.514	0.481	1.374	1.729	2.217
$H_2C_3S_2R_1$	17.55	28.29	35.26	0.354	0.480	0.497	1.257	1.755	2.152
$H_2C_3S_2R_2$	17.96	29.01	36.13	0.327	0.478	0.586	1.518	1.997	2.511
$H_2C_3S_2R_3$	20.90	33.66	41.97	0.388	0.523	0.558	1.436	1.922	2.399
$H_2C_4S_1R_1$	19.04	30.32	37.28	0.349	0.480	0.566	1.298	1.760	2.270
$H_2C_4S_1R_2$	19.45	30.95	38.08	0.363	0.492	0.569	1.356	1.747	2.302
$H_2C_4S_1R_3$	19.31	30.73	37.80	0.377	0.483	0.548	1.284	1.732	2.240
$H_2C_4S_2R_1$	19.15	30.50	37.50	0.360	0.496	0.583	1.201	1.764	2.204
$H_2C_4S_2R_2$	19.62	31.28	38.46	0.341	0.478	0.561	1.329	1.743	2.279
$H_2C_4S_2R_3$	19.31	30.76	37.83	0.370	0.488	0.365	0.575	0.994	1.207
$H_3C_1S_1R_1$	11.33	18.65	23.06	0.215	0.298	0.351	0.806	1.919	1.427
$H_3C_1S_1R_2$	11.21	18.41	22.79	0.222	0.310	0.357	0.834	1.211	1.461
$H_3C_1S_1R_3$	11.80	19.09	23.76	0.229	0.316	0.362	0.827	1.201	1.449
$H_3C_1S_2R_1$	11.44	18.82	23.28	0.227	0.306	0.368	0.844	1.233	1.483
$H_3C_1S_2R_2$	11.79	19.36	23.96	0.231	0.317	0.345	0.762	1.166	1.377
$H_3C_1S_2R_3$	12.30	18.92	24.02	0.212	0.303	0.401	0.844	1.300	1.532
$H_3C_2S_1R_1$	14.47	21.92	28.03	0.231	0.322	0.383	0.889	1.256	1.532
$H_3C_2S_1R_2$	13.78	20.94	26.71	0.242	0.314	0.418	0.858	1.384	1.601
$H_3C_2S_1R_3$	15.57	23.56	30.10	0.234	0.350	0.414	0.896	1.259	1.539
$H_3C_2S_2R_1$	13.90	21.14	26.95	0.243	0.285	0.387	0.947	1.237	1.560
$H_3C_2S_2R_2$	12.18	17.86	23.11	0.255	0.300	0.401	0.851	1.379	1.592
$H_3C_2S_2R_3$	14.14	20.74	26.83	0.233	0.365	0.444	0.954	1.439	1.709
$H_3C_3S_1R_1$	15.73	22.47	29.38	0.257	0.355	0.422	0.910	1.388	1.641
$H_3C_3S_1R_2$	14.99	21.42	28.01	0.246	0.349	0.466	1.064	1.498	1.830
$H_3C_3S_1R_3$	16.59	23.70	30.99	0.282	0.366	0.450	0.947	1.433	1.700
$H_3C_3S_2R_1$	15.65	22.35	29.23	0.255	0.346	0.439	1.016	1.454	1.765
$H_3C_3S_2R_2$	15.96	22.80	29.82	0.271	0.369	0.459	1.109	1.488	1.855
$H_3C_3S_2R_3$	16.44	23.49	30.72	0.293	0.367	0.473	1.002	1.521	1.802
$H_3C_4S_1R_1$	15.93	22.18	28.63	0.248	0.342	0.482	0.747	1.319	1.562
$H_3C_4S_1R_2$	15.91	22.15	27.93	0.235	0.332	0.474	0.909	1.319	1.677
$H_3C_4S_1R_3$	15.91	21.45	28.58	0.273	0.340	0.471	0.796	1.315	1.593
$H_3C_4S_2R_1$	15.84	22.06	28.46	0.246	0.340	0.484	0.765	1.357	1.601
$H_3C_4S_2R_2$	16.45	22.93	29.60	0.239	0.351	0.461	0.954	1.290	1.689
$H_3C_4S_2R_3$	15.48	21.55	27.80	0.283	0.337	0.501	0.960	1.295	1.680
CD at 5%	**NS**	**NS**	**NS**	**0.015**	**NS**	**0.183**	**0.191**	**0.269**	**0.248**

The interaction effect, between various factors, was significant, at most of the stages of root growth. Considering two factor interaction H_2C_4, H_2S_2, H_2R_3 and C_3R_3 exhibited highest values. Similarly, the three factors, $H_2C_4S_1$ and $C_4S_2R_1$ generated maximum values, at 25 and 45 DAS, respectively. The four factor interaction was also significant and the best one is $H_2C_3S_2$ R_2/R_3, at 45 DAS.

4.4.4 Nitrate reductase activity in the root

The activity of nitrate reductase (NR) increased significantly, over the control, in the roots of the treated plants, however, the values decreased as the growth progressed (Table 22). IAA (H_2) proved most effective, followed by GA_3 (H_1) and IBA (H_3), at the later stages of growth only (i.e., 35 and 45 DAS). The activity increased with an increase in the level of the hormones but the two highest concentrations (C_3 and C_4) were at par in their effect. Again, the soaking periods (S_1 and S_2) induced no significant effect. The hormones fed once (R_1 or R_2) induced some what similar response but their application twice (R_3) was significantly superior.

The interaction effect was largely non-significant but two and three factor interactions H_2C_4, C_3R_3 and $H_2C_3R_3$ were significant, expressing the superiority of 10^{-7} M of IAA, applied twice.

4.4.5 Nitrate content in the root

It may be derived from table 22 that the nitrate content decreased as the growth advanced but was significantly affected by the treatment. IAA (H_2) was most effective throughout the growth period, studied. The level of the nitrate increased with an increase in the level of the hormones, however,

Table 22. The level of nitrate reductase (NRA; m moles $g^{-1}h^{-1}fw$) and nitrate ($\mu g \times 10^{-3}$ g^{-1}) in the root of the plants, received water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M of GA_3 (H_1), IAA (H_2) or IBA (H_3) through seeds for 12 (S_1) or 18 (S_2) hours and with nutrient solution on 7th (R_1) or 14th (R_2) or both 7th and 14th (R_3) days, after the emergence of the seedlings. The sampling was done at 25, 35 and 45 days after sowing.

Treatments	NRA			Nitrate		
	DAYS AFTER SOWING					
	25	35	45	25	35	45
H_1	0.816	0.725	0.718	151	140	122
H_2	0.878	0.851	0.771	153	146	125
H_3	0.752	0.716	0.700	150	138	120
CD at 5%	**0.010**	**0.010**	**NS**	**3**	**2**	**2**
C_1	0.667	0.646	0.644	142	129	113
C_2	0.773	0.724	0.708	150	141	121
C_3	0.885	0.824	0.770	155	146	126
C_4	0.886	0.814	0.776	158	149	129
CD at 5%	**0.012**	**0.012**	**NS**	**4**	**3**	**3**
S_1	0.812	0.761	0.727	152	142	123
S_2	0.768	0.732	0.819	154	143	123
CD at 5%	**NS**	**NS**	**NS**	**2**	**2**	**2**
R_1	0.803	0.751	0.720	151	139	121
R_2	0.794	0.745	0.718	151	140	123
R_3	0.849	0.798	0.751	154	145	126
CD at 5%	**0.010**	**0.010**	**0.010**	**3**	**2**	**2**
H_1C_1	0.660	0.634	0.637	142	131	114
H_1C_2	0.754	0.659	0.691	149	141	123
H_1C_3	0.895	0.781	0.754	155	145	126
H_1C_4	0.906	0.777	0.769	156	145	126
H_2C_1	0.677	0.662	0.651	141	131	114
H_2C_2	0.842	0.815	0.751	158	147	127
H_2C_3	0.974	0.944	0.835	158	147	128
H_2C_4	0.979	0.934	0.836	164	154	133
H_3C_1	0.664	0.641	0.643	142	132	115
H_3C_2	0.724	0.696	0.682	148	136	118
H_3C_3	0.797	0.757	0.732	153	144	125
H_3C_4	0.773	0.721	0.724	156	145	125
CD at 5%	**0.020**	**0.021**	**0.020**	**5**	**5**	**4**
H_1S_1	0.813	0.725	0.719	151	139	121
H_1S_2	0.819	0.726	0.717	151	142	123
H_2S_1	0.875	0.848	0.787	156	145	125
H_2S_2	0.881	0.854	0.775	154	144	126
H_3S_1	0.748	0.700	0.695	150	138	120
H_3S_2	0.756	0.722	0.705	150	140	122
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

H_1R_1	0.801	0.709	0.707	151	139	121
H_1R_2	0.789	0.702	0.704	150	141	122
H_1R_3	0.859	0.765	0.743	154	143	123
H_2R_1	0.866	0.807	0.762	153	144	125
H_2R_2	0.851	0.826	0.757	155	144	124
H_2R_3	0.917	0.890	0.795	156	147	128
H_3R_1	0.742	0.709	0.691	149	137	119
H_3R_2	0.742	0.706	0.693	148	138	121
H_3R_3	0.772	0.738	0.717	153	142	122
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
C_1S_1	0.667	0.646	0.643	141	131	114
C_1S_2	0.667	0.646	0.644	143	131	113
C_2S_1	0.767	0.716	0.703	150	141	123
C_2S_2	0.780	0.731	0.713	153	142	122
C_3S_1	0.880	0.820	0.766	155	145	126
C_3S_2	0.890	0.827	0.775	158	148	127
C_4S_1	0.884	0.812	0.775	157	148	129
C_4S_2	0.918	0.816	0.777	159	148	128
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
C_1R_1	0.665	0.643	0.642	141	131	114
C_1R_2	0.671	0.651	0.648	144	132	114
C_1R_3	0.758	0.644	0.642	141	131	114
C_2R_1	0.758	0.705	0.697	152	140	121
C_2R_2	0.740	0.703	0.704	153	141	123
C_2R_3	0.822	0.763	0.724	151	142	122
C_3R_1	0.865	0.804	0.756	154	144	126
C_3R_2	0.840	0.782	0.742	155	143	124
C_3R_3	0.950	0.885	0.814	162	152	130
C_4R_1	0.874	0.800	0.764	155	146	127
C_4R_2	0.875	0.793	0.758	156	145	125
C_4R_3	0.908	0.849	0.807	162	154	134
CD at 5%	**NS**	**0.021**	**0.020**	**5**	**5**	**5**
S_1R_1	0.806	0.753	0.721	152	141	122
S_1R_2	0.784	0.735	0.711	149	139	122
S_1R_3	0.847	0.795	0.748	154	143	123
S_2R_1	0.800	0.748	0.718	150	141	122
S_2R_2	0.805	0.754	0.725	153	142	122
S_2R_3	0.851	0.800	0.755	154	145	126
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_1S_1$	0.660	0.633	0.636	142	131	113
H_1C2S1	0.739	0.647	0.687	150	138	120
$H_1C_2S_2$	0.769	0.672	0.695	151	142	123
$H_1C_3S_1$	0.894	0.786	0.758	155	144	125
$H_1C_3S_2$	0.895	0.776	0.750	157	148	129
$H_1C_4S_1$	0.910	0.784	0.774	157	146	126
$H_1C_4S_2$	0.902	0.771	0.764	156	147	128

$H_2C_1S_1$	0.677	0.662	0.651	143	131	113
$H_2C_1S_2$	0.677	0.663	0.652	141	131	114
$H_2C_2S_1$	0.840	0.815	0.747	158	148	128
$H_2C_2S_2$	0.844	0 816	0.755	155	146	127
$H_2C_3S_1$	0.960	0.929	0.818	160	149	129
$H_2C_3S_2$	0.967	0.937	0.833	156	147	129
$H_2C_4S_1$	0.973	0.936	0.831	164	154	132
$H_2C_4S_2$	0.986	0.951	0.840	162	153	133
$H_3C_4S_1$	0.665	0.643	0.643	143	131	113
$H_3C_1S_2$	0.664	0.640	0.643	142	132	115
$H_3C_2S_1$	0.720	0.687	0.675	146	135	117
$H_3C_2S_2$	0.727	0.705	0.690	147	137	120
$H_3C_3S_1$	0.787	0.744	0.722	153	142	123
$H_3C_3S_2$	0.808	0.769	0.742	155	145	126
$H_3C_4S_1$	0.770	0.716	0.720	156	145	125
$H_3C_4S_2$	0.776	0.726	0.728	155	146	127
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_1R_1$	0.660	0.630	0.634	143	131	113
$H_1C_1R_2$	0.659	0.642	0.643	141	131	114
$H_1C_1R_3$	0.660	0 630	0.634	142	131	113
$H_1C_2R_1$	0.728	0.624	0.670	149	139	122
$H_1C_2R_2$	0.711	0.631	0.685	153	142	122
$H_1C_2R_3$	0.823	0.723	0.719	149	139	122
$H_1C_3R_1$	0.872	0.767	0.744	156	145	125
$H_1C_3R_2$	0.836	0.726	0.713	154	145	126
$H_1C_3R_3$	0.976	0.850	0.806	159	148	128
$H_1C_4R_1$	0.894	0.765	0.760	154	144	126
$H_1C_4R_2$	0.898	0.670	0.756	155	144	124
$H_1C_4R_3$	0.925	0.807	0.792	161	152	132
$H_2C_1R_1$	0.670	0.657	0.649	142	131	113
$H_2C_1R_2$	0.689	0.673	0.657	142	132	115
$H_2C_1R_3$	0.673	0.657	0 648	142	131	113
$H_2C_2R_1$	0.830	0.801	0.742	155	145	126
$H_2C_2R_2$	0.785	0.763	0.729	160	149	129
$H_2C_2R_3$	0.911	0.882	0.783	155	146	127
$H_2C_3R_1$	0.947	0.914	0.813	158	147	127
$H_2C_3R_2$	0.907	0.881	0.796	153	143	125
$H_2C_3R_3$	1.037	1.004	0.867	165	156	134
$H_2C_4R_1$	0.967	0.928	0.822	161	152	132
$H_2C_4R_2$	0.974	0.926	0.824	162	152	131
$H_2C_4R_3$	0.996	0.966	0.861	165	156	136
$H_3C_1R_1$	0.664	0.647	0.642	143	131	113
$H_3C_1R_2$	0.665	0.637	0.644	143	133	116
$H_3C_1R_3$	0.664	0.644	0.643	143	131	113
$H_3C_2R_1$	0.715	0.671	0.678	145	135	118
$H_3C_2R_2$	0.724	0.715	0.698	150	138	120

$H_3C_2R_3$	0.733	0.683	0.670	145	134	117
$H_3C_3R_1$	0.777	0.732	0.711	152	141	122
$H_3C_3R_2$	0.778	0.738	0.716	151	142	123
$H_3C_3R_3$	0.836	0.800	0.768	160	149	129
$H_3C_4R_1$	0.792	0.671	0.711	152	143	125
$H_3C_4R_2$	0.782	0.684	0.693	152	141	122
$H_3C_4R_3$	0.834	0.773	0.767	161	152	132
CD at 5%	**0.026**	**NS**	**0.034**	**NS**	**NS**	**NS**
$H_1S_1R_1$	0.804	0.712	0.741	152	141	121
$H_1S_1R_2$	0.782	0.700	0.702	149	139	122
$H_1S_1R_3$	0.853	0.762	0.743	152	141	121
$H_1S_2R_1$	0.797	0.706	0.702	149	139	122
$H_1S_2R_2$	0.795	0.704	0.706	152	141	122
$H_1S_2R_3$	0.864	0.768	0.743	155	145	126
$H_2S_1R_1$	0.870	0.840	0.763	156	145	125
$H_2S_1R_2$	0.840	0.814	0.750	153	144	125
$H_2S_1R_3$	0.916	0.889	0.785	158	147	127
$H_2S_2R_1$	0.862	0.835	0.760	152	143	124
$H_2S_2R_2$	0.863	0.837	0.763	155	144	125
$H_2S_2R_3$	0.918	0.891	0.802	155	146	127
$H_3S_1R_1$	0.744	0.706	0.689	148	137	119
$H_3S_1R_2$	0.729	0.692	0.681	146	136	119
$H_3S_1R_3$	0.771	0.733	0.714	153	142	122
$H_3S_2R_1$	0.740	0.704	0.692	148	136	119
$H_3S_2R_2$	0.755	0.721	0.705	152	142	123
$H_3S_2R_3$	0.772	0.742	0.720	151	139	122
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$C_1S_1R_1$	0.674	0.655	0.648	143	133	115
$C_1S_1R_2$	0.663	0.641	0.642	142	129	113
$C_1S_1R_3$	0.666	0.642	0.640	142	133	115
$C_1S_2R_1$	0.656	0.631	0.636	141	128	113
$C_1S_2R_2$	0.680	0.661	0.654	142	132	115
$C_1S_2R_3$	0.665	0.646	0.643	141	131	114
$C_2S_1R_1$	0.759	0.706	0.701	153	142	122
$C_2S_1R_2$	0.724	0.684	0.688	150	141	123
$C_2S_1R_3$	0.817	0.759	0.721	151	139	120
$C_2S_2R_1$	0.756	0.705	0.693	148	138	121
$C_2S_2R_2$	0.756	0.721	0.720	155	144	125
$C_2S_2R_3$	0.827	0.766	0.727	152	143	123
$C_3S_1R_1$	0.869	0.804	0.752	154	143	123
$C_3S_1R_2$	0.825	0.772	0.736	152	143	124
$C_3S_1R_3$	0.947	0.883	0.810	161	151	130
$C_3S_2R_1$	0.861	0.804	0.760	155	146	127
$C_3S_2R_2$	0.855	0.792	0.747	155	144	124
$C_3S_2R_3$	0.953	0.887	0.818	205	151	159
$C_4S_1R_1$	0.772	0.796	0.765	158	149	129

$C_4S_1R_2$	0.773	0.791	0.758	155	143	125
$C_4S_1R_3$	0.907	0.846	0.802	163	153	132
$C_4S_2R_1$	0.777	0.804	0.764	155	146	127
$C_4S_2R_2$	0.777	0.793	0.757	156	145	125
$C_4S_2R_3$	0.910	0.852	0.811	163	153	133
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_1S_1R_1$	0.668	0.655	0.646	142	133	115
$H_1C_1S_1R_2$	0.695	0.679	0.665	143	131	114
$H_1C_1S_1R_3$	0.669	0.653	0.640	141	131	113
$H_1C_1S_2R_1$	0.672	0.659	0.652	142	129	113
$H_1C_1S_2R_2$	0.684	0.668	0.648	141	131	113
$H_1C_1S_2R_3$	0.677	0.662	0.656	143	131	114
$H_1C_2S_1R_1$	0.838	0.811	0.752	153	144	124
$H_1C_2S_1R_2$	0.766	0.745	0.712	148	136	119
$H_1C_2S_1R_3$	0.916	0.889	0.777	148	138	120
$H_1C_2S_2R_1$	0.822	0.792	0.732	147	135	118
$H_1C_2S_2R_2$	0.803	0.781	0.748	155	147	127
$H_1C_2S_2R_3$	0.905	0.875	0.788	152	141	123
$H_1C_3S_1R_1$	0.956	0.917	0.804	152	143	123
$H_1C_3S_1R_2$	0.887	0.865	0.791	155	144	126
$H_1C_3S_1R_3$	1.038	1.004	0.860	157	148	128
$H_1C_3S_2R_1$	0.939	0.910	0.822	158	147	128
$H_1C_3S_2R_2$	0.926	0.898	0.802	155	146	126
$H_1C_3S_2R_3$	1.037	1.004	0.874	160	152	132
$H_1C_4S_1R_1$	0.968	0.928	0.831	158	148	128
$H_1C_4S_1R_2$	0.960	0.918	0.811	152	142	124
$H_1C_4S_1R_3$	0.990	0.961	0.852	160	149	129
$H_1C_4S_2R_1$	0.956	0.929	0.813	150	141	123
$H_1C_4S_2R_2$	0.989	0.954	0.837	156	145	125
$H_1C_4S_2R_3$	1.002	0.972	0.870	163	155	134
$H_2C_1S_1R_1$	0.672	0.655	0.644	145	133	115
$H_2C_1S_1R_2$	0.652	0.626	0.635	140	129	113
$H_2C_1S_1R_3$	0.670	0.646	0.649	142	129	112
$H_2C_1S_2R_1$	0.656	0.628	0.639	138	128	112
$H_2C_1S_2R_2$	0.677	0.650	0.653	145	134	116
$H_2C_1S_2R_3$	0.658	0.643	0.636	141	131	114
$H_2C_2S_1R_1$	0.711	0.678	0.667	160	149	129
$H_2C_2S_1R_2$	0.716	0.700	0.786	156	145	126
$H_2C_2S_1R_3$	0.734	0.685	0.672	159	151	129
$H_2C_2S_2R_1$	0.719	0.704	0.689	151	139	122
$H_2C_2S_2R_2$	0.732	0.730	0.711	163	155	133
$H_2C_2S_2R_3$	0.731	0.681	0.669	154	143	124
$H_2C_3S_1R_1$	0.681	0.654	0.652	158	149	129
$H_2C_3S_1R_2$	0.641	0.617	0.625	154	143	124
$H_2C_3S_1R_3$	0.660	0.627	0.632	166	158	136
$H_2C_3S_2R_1$	0.640	0.606	0.616	157	145	127

$H_2C_3S_2R_2$	0.678	0.666	0.661	153	144	124
$H_2C_3S_2R_3$	0.661	0.634	0.637	64	153	133
$H_2C_4S_1R_1$	0.678	0.579	0.663	161	153	132
$H_2C_4S_1R_2$	0.638	0.558	0.646	162	152	132
$H_2C_4S_1R_3$	0.751	0.654	0.693	167	157	135
$H_2C_4S_2R_1$	0.677	0.570	0.637	162	153	133
$H_2C_4S_2R_2$	0.684	0.603	0.683	159	148	128
$H_2C_4S_2R_3$	0.796	0.692	0.705	164	156	135
$H_3C_1S_1R_1$	0.873	0.763	0.740	142	129	112
$H_3C_1S_1R_2$	0.836	0.740	0.724	142	132	115
$H_3C_1S_1R_3$	0.973	0.855	0.810	145	133	115
$H_3C_1S_2R_1$	0.870	0.772	0.747	143	133	116
$H_3C_1S_2R_2$	0.836	0.712	0.702	145	134	116
$H_3C_1S_2R_3$	0.979	0.845	0.802	139	128	112
$H_3C_2S_1R_1$	0.934	0.803	0.770	145	134	116
$H_3C_2S_1R_2$	0.964	0.834	0.794	146	136	119
$H_3C_2S_1R_3$	0.981	0.864	0.817	146	134	116
$H_3C_2S_2R_1$	0.953	0.827	0.789	147	137	120
$H_3C_2S_2R_2$	0.932	0.786	0.757	152	141	122
$H_3C_2S_2R_3$	0.970	0.850	0.806	145	132	116
$H_3C_3S_1R_1$	0.779	0.733	0.713	152	143	123
$H_3C_3S_1R_2$	0.753	0.711	0.694	148	136	119
$H_3C_3S_1R_3$	0.830	0.789	0.759	158	150	129
$H_3C_3S_2R_1$	0.776	0.730	0.710	150	138	121
$H_3C_3S_2R_2$	0.804	0.765	0.738	155	147	127
$H_3C_3S_2R_3$	0.842	0.812	0.778	159	96	87
$H_3C_4S_1R_1$	0.764	0.708	0.713	155	146	126
$H_3C_4S_1R_2$	0.745	0.680	0.689	150	138	121
$H_3C_4S_1R_3$	0.880	0.762	0.758	161	153	132
$H_3C_4S_2R_1$	0.760	0.704	0.710	153	142	123
$H_3C_4S_2R_2$	0.759	0.690	0.696	153	144	124
$H_3C_4S_2R_3$	0.808	0.784	0.777	162	152	132
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

the two higher concentrations (C_3 and C_4) were at par in their effect. The soaking durations remained in-significant. The addition of the hormones twice (R_3) proved superior than once (R_1 or R_2), particularly, at 35 and 45 days after sowing.

Among the interaction effect, only two factor interaction H_2C_4 and C_4 R_3 gave significantly higher values, at all the growth stages.

4.4.6 Protein content in the root

The protein level decreased as the growth progressed, but exhibited significant response to the treatment (Table 23). None of the hormones was superior in its effect, at the early stage of growth (25 DAS) but GA_3 (H_1) excelled the others, at the later stages (35 and 45 DAS). C_3 (10^{-7} M) increased the values to the largest extent. Application of the hormones twice (R_3) proved most effective, at 25 and 45 DAS. Considering the interaction effect, only H_1C_3 and C_3R_3 significantly interacted and gave maximum values.

4.4.7 Soluble carbohydrate content in the root

The treatment significantly affected the soluble carbohydrate level in the roots (Table 23). Its level increased with the age of the root. Among the hormones, IAA (H_2) was most effective and induced an effect significantly different from those of other hormones. It was followed by IBA (H_3). In general, 10^{-7} M (C_3), of the hormones proved best, however, its values were at par with that of 10^{-5} M (C_4), at the later stage of growth (45 DAS). It is evident that the hormones be applied twice (R_3) for maximum gains. Among the interactions, only two factor interaction was significant where the best combinations are H_1C_3, H_1R_3, C_3R_3 and S_1R_3.

Table 23. The per cent protein and soluble and insoluble carbohydrates in the root of the plants, received water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M of GA_3 (H_1), IAA (H_2) or IBA (H_3) through seeds for 12 (S_1) or 18 (S_2) hours and with nutrient solution on 7th (R_1) or 14th (R_2) or both 7th and 14th (R_3) days, after the emergence of the seedlings. The sampling was done at 25, 35 and 45 days, after sowing.

Treatments	Protein			Sol. carbohydrate			Insol. carbohydrate		
	DAYS AFTER SOWING								
	25	35	45	25	35	45	25	35	45
H_1	20.64	19.88	18.57	4.99	6.32	6.30	40.76	40.79	38.21
H_2	20.08	39.48	37.02	4.66	5.92	6.05	19.23	17.80	38.79
H_3	37.93	38.91	36.54	4.12	5.43	4.93	19.86	10.07	17.47
CD at 5%	**0.20**	**0.32**	**0.34**	**0.07**	**0.07**	**0.13**	**0.74**	**0.73**	**0.77**
C_1	18.66	17.58	15.94	3.55	4.73	4.71	33.80	33.18	32.56
C_2	20.12	19.35	17.82	4.36	5.69	5.68	38.09	38.37	36.51
C_3	20.84	20.14	18.80	5.04	6.37	6.18	41.25	42.29	39.14
C_4	20.15	19.50	18.22	4.90	6.27	6.18	41.50	42.07	38.82
CD at 5%	**0.34**	**0.37**	**0.30**	**0.07**	**0.08**	**0.16**	**0.84**	**0.84**	**0.89**
S_1	20.13	19.31	17.86	4.57	5.88	5.73	39.24	39.92	37.29
S_2	20.26	19.47	18.03	4.60	5.91	5.80	39.08	39.54	37.22
CD at 5%	**NS.**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
R_1	20.02	19.18	17.70	4.54	5.83	5.77	39.04	39.61	37.03
R_2	20.07	19.26	17.78	4.46	5.77	5.61	38.39	38.81	34.69
R_3	20.49	17.74	18.36	4.76	6.07	5.91	40.05	40.76	38.06
CD at 5%	**0.20**	**0.32**	**0.34**	**0.07**	**0.07**	**0.14**	**0.73**	**0.73**	**0.77**
H_1C_1	18.63	17.53	15.89	3.56	4.73	4.84	33.81	33.19	32.53
H_1C_2	20.98	20.39	18.96	4.72	6.14	6.31	39.45	39.29	37.78
H_1C_3	21.14	20.40	19.29	5.61	6.95	6.97	43.52	43.81	40.18
H_1C_4	20.81	20.21	19.14	5.76	6.97	6.80	44.22	43.88	39.33
H_2C_1	18.62	17.53	15.89	3.53	4.71	4.70	34.10	33.38	32.62
H_2C_2	19.97	19.13	17.61	4.47	5.76	5.92	37.84	38.20	36.27
H_2C_3	20.85	20.14	18.82	5.13	6.38	6.57	40.52	41.81	38.91
H_2C_4	19.87	19.11	17.90	5.00	6.32	6.74	40.68	41.52	38.28
H_3C_1	18.74	17.67	16.04	3.55	4.74	4.58	33.48	32.97	32.52
H_3C_2	19.42	18.52	16.90	3.90	5.16	4.82	36.95	37.61	35.48
H_3C_3	20.52	19.88	18.30	4.39	5.78	5.00	39.69	41.25	38.33
H_3C_4	19.78	19.20	17.63	4.33	5.54	5.02	39.61	40.81	36.85
CD at 5%	**0.58**	**0.63**	**0.69**	**0.13**	**0.130**	**0.27**	**1.47**	**NS**	**NS**
H_1S_1	20.71	19.98	18.66	4.95	6.30	6.24	40.77	.40.93	38.34
H_1S_2	20.57	19.78	18.48	5.02	6.35	6.37	40.75	40.65	38.01
H_2S_1	19.94	19.40	17.62	4.65	5.91	5.96	38.82	39.64	36.96
H_2S_2	20.22	19.78	17.99	4.67	5.92	6.15	38.75	39.32	37.07
H_3S_1	19.74	18.91	17.30	4.12	5.41	4.99	38.13	39.18	36.56
H_3S_2	19.99	19.23	17.63	4.12	5.45	4.87	37.73	38.64	36.53
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

H_1R_1	20.47	19.67	17.59	4.92	6.24	6.32	40.58	40.64	37.96
H_1R_2	20.51	19.75	17.65	4.81	6.15	6.13	39.77	39.73	37.56
H_1R_3	20.94	20.23	18.16	5.23	6.59	6.46	41.93	42.02	39.10
H_2R_1	19.93	19.06	18.34	4.62	5.88	6.03	38.05	39.35	36.82
H_2R_2	19.98	19.12	18.69	4.51	5.80	5.87	38.09	38.61	36.49
H_2R_3	20.32	19.49	18.99	4.85	6.07	6.26	39.62	40.48	37.75
H_3R_1	19.64	18.80	17.19	4.08	5.36	4.96	37.88	38.84	36.30
H_3R_2	19.23	18.91	17.30	4.07	5.37	4.83	37.32	38.09	36.01
H_3R_3	20.22	19.51	17.91	4.20	5.56	5.00	38.60	39.80	37.32
CD at 5%	**NS**	**NS**	**NS**	**0.12**	**0.11**	**NS**	**NS**	**NS**	**NS**
C_1S_1	18.64	17.54	15.91	3.55	4.73	4.70	33.60	32.87	32.38
C_1S_2	18.69	17.61	15.97	3.54	4.73	4.72	33.39	33.49	32.73
C_2S_1	20.04	19.24	17.71	4.34	5.65	5.77	38.96	39.83	37.16
C_2S_2	20.21	19.45	17.94	4.39	5.73	5.60	37.23	36.90	35.86
C_3S_1	20.69	19.96	18.63	5.01	6.35	6.05	40.97	41.96	38.86
C_3S_2	20.98	20.32	18.98	5.07	6.39	6.30	41.52	42.63	39.44
C_4S_1	20.15	19.51	18.20	4.89	6.27	6.11	41.42	42.01	38.78
C_4S_2	20.15	19.50	18.24	4.91	6.28	6.26	41.58	42.13	38.86
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**1.10**	**1.99**	**NS**
C_1R_1	18.63	17.54	15.90	4.54	4.72	4.74	33.64	32.88	34.54
C_1R_2	18.76	17.70	16.06	3.56	4.75	4.70	33.69	33.04	33.56
C_1R_3	18.60	17.50	15.86	3.55	4.72	4.68	34.06	33.63	33.55
C_2R_1	19.97	19.18	17.61	4.31	5.62	5.86	38.50	38.99	36.68
C_2R_2	20.46	19.83	18.24	4.07	5.48	5.19	36.00	35.60	35.46
C_2R_3	19.93	19.03	17.62	4.71	5.96	6.00	39.79	40.50	37.39
C_3R_1	20.57	19.82	18.45	4.94	6.27	6.17	40.63	41.63	38.55
C_3R_2	20.39	19.60	18.22	4.79	6.11	5.96	39.99	40.94	38.04
C_3R_3	21.55	21.01	19.75	5.40	6.73	6.4	43.11	44.31	40.82
C_4R_1	19.89	19.17	17.86	4.87	6.20	6.01	41.37	41.94	38.50
C_4R_2	19.69	18.91	17.60	4.94	6.24	6.28	41.90	42.66	38.67
C_4R_3	20.88	20.43	19.20	4.89	6.38	6.26	41.23	41.61	39.29
CD at 5%	**0.50**	**0.63**	**0.69**	**0.13**	**0.13**	**0.27**	**1.47**	**1.46**	**NS**
S_1R_1	20.05	19.22	17.73	4.56	5.15	5.77	39.19	39.81	37.15
S_1R_2	19.95	19.11	17.62	4.40	5.69	5.52	38.21	38.66	36.50
S_1R_3	20.39	19.60	18.22	4.75	6.08	5.90	40.32	41.28	38.22
S_2R_1	19.98	19.13	17.67	4.52	5.80	5.76	38.88	39.41	36.90
S_2R_2	20.20	19.41	17.94	4.53	5.85	5.70	38.57	38.96	36.88
S_2R_3	20.00	19.88	18.49	4.77	6.07	5.92	39.28	40.24	37.90
CD at 5%	**NS**	**NS**	**NS**	**0.09**	**0.09**	**NS**	**NS**	**NS**	**NS**
$H_1C_1S_1$	18.61	17.51	15.87	3.58	4.75	4.83	33.36	32.91	32.37
$H_1C_1S_2$	18.65	17.55	15.91	3.54	4.72	4.85	33.96	33.47	32.68
$H_1C_2S_1$	21.11	20.57	19.09	4.62	6.07	6.31	40.06	40.56	38.53
$H_1C_2S_2$	20.86	20.22	18.82	4.82	6.21	6.31	38.91	38.03	37.03
$H_1C_3S_1$	21.22	20.52	19.41	5.55	6.91	6.85	43.19	43.43	40.07

$H_1C_3S_2$	21.06	20.29	19.18	5.97	6.99	7.10	43.85	44.18	40.28
$H_1C_4S_1$	20.90	20.33	19.27	5.76	6.98	6.37	44.16	43.83	40.40
$H_1C_4S_2$	20.71	20.08	19.01	5.77	6.96	6.92	44.27	43.93	40.26
$H_2C_1S_1$	18.59	17.49	15.85	3.54	4.71	4.69	33.80	33.10	32.45
$H_2C_1S_2$	18.66	17.57	15.93	3.53	4.71	4.70	34.25	33.67	32.79
$H_2C_2S_1$	19.76	18.85	17.35	4.46	5.71	5.88	38.54	39.55	36.75
$H_2C_2S_2$	20.18	19.41	17.86	4.49	5.82	5.96	37.14	36.85	35.79
$H_2C_3S_1$	20.56	19.77	18.47	5.12	6.43	6.36	40.27	41.49	38.48
$H_2C_3S_2$	21.14	20.51	19.17	5.14	6.32	6.77	40.78	42.13	39.34
$H_2C_4S_1$	19.85	19.09	17.81	4.98	6.30	6.63	40.52	41.41	38.19
$H_2C_4S_2$	19.89	19.12	17.98	5.02	6.34	6.85	40.83	41.64	38.37
$H_3C_1S_1$	18.71	17.64	16.00	3.55	4.74	4.57	33.20	32.60	32.31
$H_3C_1S_2$	18.77	17.71	16.07	3.55	4.75	4.60	33.75	33.33	32.73
$H_3C_2S_1$	19.25	19.20	16.68	3.93	5.17	5.12	38.28	39.37	36.20
$H_3C_2S_2$	19.59	18.75	17.13	3.86	5.16	4.53	35.63	35.84	34.76
$H_3C_3S_1$	20.29	19.59	18.01	4.36	5.92	4.96	39.46	40.95	37.96
$H_3C_3S_2$	20.74	20.17	18.59	4.42	5.84	5.03	39.92	41.56	38.70
$H_3C_4S_1$	19.69	19.10	17.52	4.13	5.52	5.02	39.59	40.79	37.76
$H_3C_4S_2$	19.86	19.31	17.74	4.13	5.55	5.02	39.62	40.83	37.94
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_1R_1$	18.57	17.44	15.80	3.60	4.74	4.95	33.91	33.05	32.39
$H_1C_1R_2$	18.75	17.69	16.05	3.47	4.67	4.59	33.35	32.84	32.47
$H_1C_1R_3$	18.58	17.47	15.85	3.61	4.77	4.88	34.13	33.68	32.72
$H_1C_2R_1$	20.75	20.11	18.61	4.67	6.06	6.40	39.88	39.91	37.87
$H_1C_2R_2$	21.41	21.01	18.43	4.36	5.90	5.75	37.05	36.31	36.70
$H_1C_2R_3$	20.78	20.04	18.81	5.12	6.47	6.78	41.53	41.66	38.78
$H_1C_3R_1$	20.94	20.16	19.04	5.40	6.74	6.95	42.55	42.90	39.54
$H_1C_3R_2$	20.34	19.42	18.35	5.28	6.53	6.81	41.90	42.25	38.65
$H_1C_3R_3$	22.14	21.63	20.59	6.14	7.59	7.14	46.05	46.27	42.35
$H_1C_4R_1$	20.62	19.97	18.90	5.50	6.88	6.68	43.97	43.67	40.05
$H_1C_4R_2$	20.55	19.38	18.80	5.62	6.98	6.95	44.55	44.50	40.40
$H_1C_4R_3$	21.25	20.77	19.73	5.56	7.04	6.77	44.00	43.46	40.55
$H_2C_1R_1$	18.66	17.57	15.93	3.48	4.67	4.67	33.85	33.02	32.47
$H_2C_1R_2$	18.64	17.53	15.89	3.61	4.78	4.78	34.29	33.44	32.65
$H_2C_1R_3$	18.58	17.48	15.84	3.52	4.69	4.63	34.15	33.69	32.73
$H_2C_2R_1$	19.84	18.99	17.40	4.44	5.72	6.19	38.12	38.74	36.41
$H_2C_2R_2$	20.19	19.47	17.88	4.14	5.50	5.40	36.03	35.63	35.21
$H_2C_2R_3$	19.88	18.93	17.54	4.84	6.07	6.18	39.37	40.22	37.19
$H_2C_3R_1$	20.70	19.99	18.60	5.07	6.41	6.62	40.05	41.24	38.48
$H_2C_3R_2$	20.66	19.95	18.56	4.79	6.15	6.21	39.10	40.34	38.00
$H_2C_3R_3$	21.19	20.50	19.30	5.52	6.57	6.87	42.43	43.86	40.24
$H_2C_4R_1$	19.54	18.70	17.43	4.98	6.25	6.36	40.39	41.42	37.90
$H_2C_4R_2$	19.43	18.55	17.28	5.01	6.26	6.80	40.93	42.02	38.10
$H_2C_4R_3$	20.64	20.06	18.97	5.03	6.46	7.06	40.51	41.13	38.83

$H_3C_1R_1$	18.68	17.60	15.97	3.54	4.73	4.60	33.17	32.56	32.26
$H_3C_1R_2$	18.90	17.87	16.24	3.59	4.80	4.63	33.37	32.83	32.60
$H_3C_1R_3$	18.64	17.54	15.91	3.51	4.69	4.53	33.89	33.52	32.70
$H_3C_2R_1$	19.33	18.44	16.81	3.82	5.08	4.99	37.49	38.32	35.77
$H_3C_2R_2$	19.78	19.01	17.40	3.71	5.05	4.43	34.91	34.88	34.48
$H_3C_2R_3$	19.14	18.11	16.50	4.16	5.35	5.05	38.46	39.62	36.19
$H_3C_3R_1$	20.06	19.30	17.71	4.35	5.67	4.93	39.31	40.74	37.64
$H_3C_3R_2$	20.16	19.43	17.84	4.30	5.64	4.86	38.91	40.22	37.47
$H_3C_3R_3$	21.33	20.92	19.35	4.54	6.04	5.19	40.86	42.81	39.88
$H_3C_4R_1$	19.50	18.84	17.26	4.12	5.48	5.01	39.54	40.72	37.53
$H_3C_4R_2$	19.09	18.31	16.72	4.19	5.48	5.10	40.09	41.45	37.51
$H_3C_4R_3$	20.75	20.45	18.90	4.08	5.64	4.95	39.19	40.25	38.51
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1S_1R_1$	20.65	19.90	18.55	4.94	6.28	6.35	40.93	40.84	38.23
$H_1S_1R_2$	20.47	19.70	18.34	4.73	5.07	5.95	39.53	39.54	37.42
H_1S_1R3	21.02	20.34	19.08	5.18	6.55	6.40	42.04	42.43	39.35
$H_1S_2R_1$	20.29	19.43	18.12	4.90	6.19	6.28	40.42	40.44	37.69
$H_1S_2R_2$	20.56	19.80	18.44	4.89	6.22	6.30	40.01	39.92	37.69
$H_1S_2R_3$	20.86	20.11	18.89	5.29	6.63	6.53	41.82	41.60	38.81
$H_2S_1R_1$	19.97	19.11	17.61	4.65	5.92	5.98	38.81	39.56	36.94
$H_2S_1R_2$	19.92	19.06	17.56	4.45	5.74	5.77	37.84	38.41	36.33
$H_2S_1R_3$	19.93	18.98	17.69	4.84	6.08	6.14	39.81	40.95	37.62
$H_2S_2R_1$	19.90	19.02	17.57	4.59	5.85	6.08	38.50	39.15	36.69
$H_2S_2R_2$	20.04	19.19	17.75	4.57	5.86	5.97	38.33	38.80	36.64
$H_2S_2R_3$	20.71	20.00	18.64	4.86	6.06	6.38	39.42	40.01	37.88
$H_3S_1R_1$	19.53	18.65	17.04	4.10	5.36	4.98	38.02	39.03	36.29
$H_3S_1R_2$	19.48	18.58	16.97	4.02	5.28	4.84	37.27	38.03	35.74
$H_3S_1R_3$	20.20	19.45	17.90	4.24	5.59	5.15	39.11	40.48	37.65
$H_3S_2R_1$	19.75	18.94	17.34	4.06	5.36	4.93	37.73	38.64	36.31
$H_3S_2R_2$	19.99	19.24	17.63	4.12	5.46	4.82	37.37	38.16	36.29
$H_3S_2R_3$	20.23	19.52	17.93	4.16	5.53	4.86	38.09	39.12	36.99
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$C_1S_1R_1$	18.64	17.54	15.90	3.56	4.73	4.76	33.64	32.80	32.34
$C_1S_1R_2$	18.69	17.61	15.97	3.53	4.72	4.64	33.25	32.35	32.17
$C_1S_1R_3$	18.59	17.48	15.84	3.57	4.74	4.69	33.92	33.46	32.62
$C_1S_2R_1$	18.63	17.53	15.90	3.53	4.70	4.72	33.65	32.95	32.41
$C_1S_2R_2$	18.83	17.78	16.15	3.58	4.79	4.76	33.13	33.72	32.98
$C_1S_2R_3$	18.61	17.51	15.87	3.52	4.69	4.67	34.19	33.80	32.81
$C_2S_1R_1$	20.19	19.46	17.87	4.33	5.67	5.82	38.83	39.57	37.17
$C_2S_1R_2$	20.07	19.33	17.74	4.01	5.37	5.35	37.13	37.58	36.08
$C_2S_1R_3$	19.85	18.92	17.52	4.67	5.91	6.14	40.89	42.32	38.22
$C_2S_2R_1$	19.75	18.90	17.34	4.29	5.57	5.89	38.17	38.41	36.19
$C_2S_2R_2$	20.86	20.33	18.75	4.13	5.60	5.04	34.83	33.62	34.85
$C_2S_2R_3$	20.02	19.13	17.71	4.75	6.01	5.87	38.69	38.68	36.55

$C_3S_1R_1$	20.35	19.53	18.16	4.99	6.29	6.21	40.87	41.84	38.45
$C_3S_1R_2$	20.35	19.56	18.18	4.66	5.99	5.75	39.00	39.67	37.38
$C_3S_1R_3$	21.38	20.79	19.54	5.38	6.79	6.19	43.05	44.36	40.69
$C_3S_2R_1$	20.79	20.10	18.74	4.88	6.26	6.12	40.49	41.41	38.66
$C_3S_2R_2$	20.43	19.63	18.25	4.92	6.23	6.17	40.98	42.20	38.70
$C_3S_2R_3$	21.73	21.24	19.95	5.42	6.67	6.61	43.17	44.26	40.96
$C_4S_1R_1$	20.01	19.35	18.00	4.87	6.23	6.00	41.41	42.02	38.66
$C_4S_1R_2$	19.71	18.95	17.61	4.90	6.21	6.05	41.45	42.02	38.36
$C_4S_1R_3$	20.72	20.22	18.99	4.89	6.36	6.27	41.42	42.00	39.33
$C_4S_2R_1$	19.76	18.99	17.72	4.86	6.18	6.03	41.32	41.86	38.34
$C_4S_2R_2$	19.67	18.88	17.60	4.98	6.27	6.51	42.36	43.30	38.97
$C_4S_2R_3$	20.64	20.64	19.42	4.88	6.40	6.25	41.05	41.33	39.26
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_1S_1R_1$	18.91	17.88	16.25	3.67	4.87	5.03	34.08	33.09	32.74
$H_1C_1S_1R_2$	18.40	17.25	15.61	3.43	4.59	4.60	32.89	32.12	31.78
$H_1C_1S_1R_3$	18.53	17.40	15.76	3.63	4.78	4.84	34.02	33.52	32.60
$H_1C_1S_2R_1$	18.22	17.00	15.35	3.53	4.65	4.86	33.74	33.01	32.04
$H_1C_1S_2R_2$	19.09	18.13	16.50	3.51	4.76	4.78	33.90	33.57	33.16
$H_1C_1S_2R_3$	18.63	17.53	15.89	3.58	4.76	4.91	34.25	33.84	32.85
$H_1C_2S_1R_1$	21.35	20.89	19.34	4.63	6.13	6.35	40.03	40.37	38.66
$H_1C_2S_1R_2$	21.00	20.51	18.93	4.25	5.73	5.80	37.95	38.10	37.22
$H_1C_2S_1R_3$	20.97	20.30	19.00	4.97	6.36	6.77	42.20	43.20	39.72
$H_1C_2S_2R_1$	20.15	19.32	17.88	4.70	6.00	6.44	39.73	39.45	37.07
$H_1C_2S_2R_2$	21.82	21.52	19.97	5.48	6.07	5.70	36.15	34.51	36.19
$H_1C_2S_2R_3$	20.60	19.77	18.61	5.27	6.57	6.78	40.86	40.13	37.84
$H_1C_3S_1R_1$	20.88	20.09	18.96	5.47	6.79	7.06	42.86	43.16	39.61
$H_1C_3S_1R_2$	20.57	19.72	18.57	5.13	6.44	6.60	40.96	40.98	38.24
$H_1C_3S_1R_3$	22.22	21.74	20.70	6.04	7.52	6.84	45.75	46.16	42.37
$H_1C_3S_2R_1$	21.01	20.24	19.12	5.34	6.69	6.84	42.24	42.65	39.47
$H_1C_3S_2R_2$	20.12	19.12	17.94	5.42	6.63	7.03	42.97	43.53	39.06
$H_1C_3S_2R_3$	22.06	21.52	20.47	6.24	7.66	7.44	46.34	46.37	42.33
$H_1C_4S_1R_1$	20.45	19.76	18.67	5.49	6.84	6.68	43.95	43.71	39.91
$H_1C_4S_1R_2$	20.90	20.32	19.27	5.61	7.03	6.50	44.33	43.94	40.45
$H_1C_4S_1R_3$	21.35	20.91	19.88	5.57	7.06	6.85	44.19	43.85	40.84
$H_1C_4S_2R_1$	20.80	20.18	19.12	5.52	6.93	6.67	43.98	43.63	40.19
$H_1C_4S_2R_2$	20.19	19.43	18.33	5.63	6.93	6.00	45.03	45.09	40.35
$H_1C_4S_2R_3$	21.14	20.63	19.59	5.55	7.01	6.23	43.81	43.07	40.25
$H_2C_1S_1R_1$	18.56	17.45	15.81	3.47	4.64	4.67	33.78	32.90	32.32
$H_2C_1S_1R_2$	18.95	17.93	16.30	3.64	4.85	4.81	34.06	32.90	32.68
$H_2C_1S_1R_3$	18.27	17.08	15.43	3.51	4.63	4.60	34.00	33.50	32.34
$H_2C_1S_2R_1$	18.76	17.70	16.06	3.49	4.69	4.68	33.92	33.13	32.62
$H_2C_1S_2R_2$	18.32	17.13	15.48	3.58	4.70	4.76	34.52	33.98	32.62
$H_2C_1S_2R_3$	18.89	17.88	16.24	3.53	4.75	4.67	34.30	33.88	33.13
$H_2C_2S_1R_1$	20.16	19.39	17.81	4.47	5.79	6.03	38.43	39.31	37.00

$H_2C_2S_1R_2$	19.70	18.86	17.25	4.04	5.34	5.41	36.85	37.37	35.62
$H_2C_2S_1R_3$	19.41	18.30	17.00	4.86	6.01	6.20	40.35	41.97	37.62
$H_2C_2S_2R_1$	19.52	18.59	16.98	4.42	5.64	6.34	37.82	38.18	35.83
$H_2C_2S_2R_2$	20.67	20.09	18.51	4.24	5.67	5.39	35.21	33.88	34.80
$H_2C_2S_2R_3$	20.35	19.57	18.09	4.83	6.14	6.15	38.39	38.48	36.76
$H_2C_3S_1R_1$	20.08	19.18	17.78	5.16	6.39	6.63	40.38	41.51	38.02
$H_2C_3S_1R_2$	20.82	20.16	18.77	4.66	6.06	5.93	38.03	39.03	37.50
$H_2C_3S_1R_3$	20.79	19.98	18.85	5.53	6.83	6.51	42.40	43.93	39.94
$H_2C_3S_2R_1$	21.33	20.80	19.42	4.98	6.43	6.60	39.72	40.96	38.94
$H_2C_3S_2R_2$	20.50	19.73	18.34	4.92	6.24	6.48	40.16	41.65	38.50
$H_2C_3S_2R_3$	21.58	21.01	19.75	5.51	6.30	7.24	42.46	43.78	40.57
$H_2C_4S_1R_1$	20.06	19.40	18.04	5.00	6.35	6.30	40.65	41.50	38.44
$H_2C_4S_1R_2$	19.21	18.30	16.91	4.97	6.19	6.63	40.43	41.34	37.53
$H_2C_4S_1R_3$	20.27	16.58	18.47	4.99	6.37	6.95	40.49	41.38	38.59
$H_2C_4S_2R_1$	19.01	18.00	16.82	4.96	6.14	6.41	40.53	41.34	37.37
$H_2C_4S_2R_2$	19.65	18.80	17.66	5.05	6.33	6.96	41.44	42.69	38.66
$H_2C_4S_2R_3$	21.01	20.55	19.48	5.07	6.56	7.17	40.53	40.89	39.07
$H_3C_1S_1R_1$	18.44	17.30	15.65	3.53	4.68	4.58	33.06	32.42	31.96
$H_3C_1S_1R_2$	18.72	17.65	16.01	3.52	4.71	4.51	32.79	32.05	32.04
$H_3C_1S_1R_3$	18.98	17.97	16.34	3.59	4.81	4.63	33.76	33.35	32.93
$H_3C_1S_2R_1$	18.92	17.91	16.28	3.55	4.78	4.62	33.28	32.70	32.56
$H_3C_1S_2R_2$	19.07	18.09	16.46	3.66	4.90	4.74	33.96	33.61	33.16
$H_3C_1S_2R_3$	18.30	17.12	15.47	3.44	4.57	4.42	34.02	33.69	32.47
$H_3C_2S_1R_1$	19.07	18.08	16.45	3.89	5.10	5.08	38.03	39.04	35.86
$H_3C_2S_1R_2$	19.50	18.64	17.02	3.74	5.03	4.84	36.71	37.28	35.40
$H_3C_2S_1R_3$	19.18	18.37	16.56	4.17	5.37	5.94	40.10	41.80	37.32
$H_3C_2S_2R_1$	19.59	18.00	17.18	3.75	5.06	4.90	36.95	37.60	35.67
$H_3C_2S_2R_2$	20.07	19.39	17.78	3.68	5.07	4.02	33.11	32.48	33.55
$H_3C_2S_2R_3$	19.10	18.05	16.44	4.15	5.34	4.67	36.83	37.44	35.06
$H_3C_3S_1R_1$	20.09	19.33	17.74	4.36	5.68	4.94	39.38	40.85	37.91
$H_3C_3S_1R_2$	19.67	18.80	17.20	4.19	5.46	4.71	38.01	39.01	36.40
$H_3C_3S_1R_3$	21.12	20.65	19.08	4.55	6.02	5.21	40.99	42.99	39.77
$H_3C_3S_2R_1$	20.03	19.27	17.67	4.34	5.65	4.92	39.23	40.64	37.56
$H_3C_3S_2R_2$	20.66	20.05	18.47	4.41	5.82	5.02	39.82	41.42	38.54
$H_3C_3S_2R_3$	21.54	21.19	19.63	4.52	6.06	5.17	40.72	42.62	39.99
$H_3C_4S_1R_1$	19.53	18.88	17.30	4.13	5.50	5.02	39.62	40.83	37.62
$H_3C_4S_1R_2$	19.01	18.23	16.64	4.13	5.41	5.01	39.58	40.77	37.11
$H_3C_4S_1R_3$	20.54	19.19	18.62	4.13	5.65	5.01	39.58	40.77	38.56
$H_3C_4S_2R_1$	19.46	18.80	17.22	4.11	5.47	4.99	39.46	40.62	37.45
$H_3C_4S_2R_2$	19.16	18.39	16.81	4.25	5.50	5.18	40.60	42.13	37.91
$H_3C_4S_2R_3$	20.97	20.73	19.18	4.03	5.64	4.88	38.80	39.73	38.45
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

4.4.8 Insoluble carbohydrate content in the root

The per cent content of insoluble carbohydrate increased significantly by the treatment (Table 23). The values exhibited an increase upto 35 DAS, but decreased thereafter (45 DAS). IAA (H_2) was far superior in its effect than the two other hormones (H_1 and H_3) whose effect was almost comparable with each other. The hormonal concentration 10^{-7}M (C_3) proved superior but its effect was comparable with that of the other higher concentration 10^{-5}M (C_4). The values were maximum in the plants receiving hormone twice (R_3) but was closely followed by R_1. Two factor interaction was significant, at early growth stages only where the best combinations are H_1C_4, at 25 DAS only and C_4S_2, C_3S_2 and C_3R_3, at 25 and 35 DAS.

4.4.9 Nitrogen, phosphorus and potassium contents in the root

The values for all these elements increased significantly by the treatment (Table 24). However, as the growth progressed their per cent content decreased. GA_3 (H_1) was most prominent in its effect by increasing the content of these nutrients to a significantly highest level and was closely followed by IAA (H_2), at all the stages of growth. The level of all the elements increased with an increase in the hormonal concentrations upto 10^{-7} M (C_3). Application of hormones twice (R_3) increased the nitrogen and potassium contents significantly, but the phosphorus level did not change.

The interaction effect was largely significant for N and P where H_1C_4, H_1S_1, C_3R_3 and C_3S_2 proved to be superior, among the two factor interactions. Significance was also noted at the three ($H_1S_1R_3$) and four ($H_1C_3S_1R_3$) factor interactions. It states that the seedlings raised from the seeds pre-treated with GA_3 (10^{-7}M) for 12 hours, supplied with 10^{-7}M of

Table 24. The per cent nitrogen, phosphorus and potassium in the root of the plants, received water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M of GA_3 (H_1), IAA (H_2) or IBA (H_3) through the seeds for 12 (S_1) or 18 (S_2) hours and with nutrient solution on 7th (R_1) or 14th (R_2) or both 7th and 14th (R_3) days, after the emergence of the seedlings. The sampling was done at 25, 35 and 45 days, after sowing.

Treatments	Nitrogen			Phosphorus			Potassium		
	DAYS AFTER SOWING								
	25	35	45	25	35	45	25	35	45
H_1	3.38	3.26	3.05	0.362	0.355	0.323	3.23	2.92	2.81
H_2	3.29	3.16	2.93	0.372	0.345	0.315	3.08	2.80	2.70
H_3	3.26	3.13	2.87	0.358	0.342	0.312	3.01	2.76	2.69
CD at 5%	**0.072**	**0.031**	**0.028**	**0.008**	**0.008**	**0.009**	**0.078**	**0.027**	**0.027**
C_1	3.07	2.89	2.63	0.338	0.321	0.294	2.71	2.49	2.43
C_2	3.30	3.18	2.93	0.363	0.346	0.316	3.08	2.82	2.73
C_3	3.41	3.30	3.09	0.375	0.359	0.326	3.28	2.97	2.86
C_4	3.46	3.26	3.06	0.361	0.314	0.320	3.26	2.93	2.82
CD at 5%	**0.08**	**0.03**	**0.03**	**0.009**	**0.009**	**0.010**	**0.09**	**0.03**	**0.03**
S_1	3.30	3.17	2.94	0.363	0.346	0.316	3.09	2.81	2.72
S_2	3.32	3.20	2.97	0.365	0.349	0.318	3.12	2.84	2.75
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
R_1	3.28	3.15	2.91	0.361	0.344	0.314	3.06	2.79	2.70
R_2	3.29	3.16	2.92	0.362	0.345	0.315	3.07	2.80	2.72
R_3	3.36	3.24	3.02	0.369	0.353	0.321	3.18	2.89	2.79
CD at 5%	**NS**	**0.03**	**0.28**	**NS**	**NS**	**NS**	**0.07**	**0.03**	**0.02**
H_1C_1	3.06	2.89	2.62	0.337	0.320	0.294	2.70	2.48	2.42
H_1C_2	3.44	3.34	3.11	0.378	0.362	0.328	3.30	3.01	2.91
H_1C_3	3.46	3.34	3.17	0.381	0.364	0.330	3.37	3.02	2.89
H_1C_4	3.57	3.37	3.20	0.373	0.355	0.330	3.44	3.07	2.93
H_2C_1	3.06	2.88	2.62	0.337	0.320	0.294	2.70	2.48	2.42
H_2C_2	3.28	3.14	2.90	0.360	0.344	0.313	3.05	2.78	2.69
H_2C_3	3.42	3.30	3.09	0.376	0.359	0.326	3.28	2.97	2.86
H_2C_4	3.42	3.10	3.00	0.356	0.309	0.316	3.10	2.86	2.74
H_3C_1	3.08	2.91	2.65	0.339	0.322	0.295	2.73	2.51	2.45
H_3C_2	3.19	3.04	2.78	0.357	0.334	0.305	2.90	2.66	2.60
H_3C_3	3.36	3.26	3.01	0.369	0.354	0.321	3.17	2.91	2.83
H_3C_4	3.40	3.21	2.96	0.354	0.338	0.315	3.14	2.87	2.79
CD at 5%	**NS**	**0.06**	**0.05**	**NS**	**NS**	**NS**	**0.15**	**0.13**	**0.05**
H_1S_1	3.39	3.18	3.07	0.373	0.356	0.324	3.24	2.94	2.83
H_1S_2	3.37	3.13	3.04	0.371	0.354	0.322	3.21	2.90	2.79
H_2S_1	3.27	3.25	2.90	0.360	0.343	0.313	3.05	2.76	2.67
H_2S_2	3.31	3.28	2.96	0.365	0.348	0.317	3.12	2.83	2.74
H_3S_1	3.24	3.10	2.85	0.356	0.340	0.310	2.98	2.73	2.66

H_3S_2	3.28	3.16	2.90	0.360	0.344	0.314	3.04	2.79	2.72
CD at 5%	**NS**	**0.04**	**0.04**	**NS**	**NS**	**NS**	**NS**	**0.047**	**0.03**
H_1R_1	3.36	3.23	3.01	0.369	0.352	0.321	3.19	2.88	2.78
H_1R_2	3.36	3.24	3.02	0.370	0.353	0.321	3.19	2.89	2.79
H_1R_3	3.43	3.32	3.12	0.377	0.360	0.327	3.31	2.98	2.87
H_2R_1	3.27	3.13	2.89	0.360	0.343	0.313	3.04	2.77	2.68
H_2R_2	3.28	3.14	2.90	0.361	0.344	0.313	3.05	2.78	2.69
H_2R_3	3.33	3.20	2.99	0.367	0.350	0.318	3.15	2.85	2.75
H_3R_1	3.22	3.09	3.83	0.354	0.338	0.309	2.95	2.71	2.64
H_3R_2	3.24	3.10	3.85	0.356	0.340	0.310	2.98	2.73	2.66
H_3R_3	3.31	3.20	2.95	0.364	0.348	0.317	3.10	2.84	2.77
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS.**	**NS**	**NS**	**NS**
C_1S_1	3.06	2.89	2.63	0.337	0.320	0.294	2.70	2.48	2.42
C_1S_2	3.07	2.90	2.64	0.338	0.321	0.295	2.72	2.50	2.43
C_2S_1	3.29	3.16	2.91	0.361	0.345	0.314	3.06	2.80	2.71
C_2S_2	3.31	3.19	2.95	0.364	0.348	0.317	3.10	2.84	2.75
C_3S_1	3.39	3.07	3.06	0.373	0.356	0.324	3.24	2.93	2.83
C_3S_2	3.44	3.33	3.12	0.378	0.361	0.328	3.31	3.00	2.89
C4S1	3.46	3.26	3.05	0.361	0.344	0.320	3.26	2.93	2.82
C_4S_2	3.46	3.26	3.06	0.361	0.344	0.321	3.26	2.93	2.02
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
C_1R_1	3.06	2.89	2.62	0.337	0.320	0.294	2.70	2.48	2.42
C_1R_2	3.08	2.91	2.65	0.339	0.322	0.296	2.73	2.51	2.45
C_1R_3	3.06	2.88	2.62	0.337	0.320	0.293	2.69	2.47	2.41
C_2R_1	3.28	3.15	2.90	0.360	0.344	0.313	3.04	2.79	2.71
C_2R_2	3.35	3.25	3.00	0.368	0.353	0.320	3.16	2.90	2.83
C_2R_3	3.27	3.12	2.90	0.360	0.343	0.313	3.05	2.76	2.67
C_3R_1	3.37	3.25	3.03	0.371	0.354	0.322	3.21	2.91	2.81
C_3R_2	3.34	3.22	2.99	0.368	0.351	0.319	3.16	2.87	2.77
C_3R_3	3.53	3.44	3.24	0.388	0.371	0.336	3.46	3.13	3.01
C_4R_1	3.42	3.21	3.00	0.356	0.339	0.317	3.19	2.87	2.76
C_4R_2	3.39	3.17	2.96	0.353	0.336	0.314	3.14	2.83	2.72
C_4R_3	3.58	3.41	3.21	0.373	0.357	0.331	3.44	3.10	2.99
CD at 5%	**NS**	**0.06**	**0.05**	**NS**	**NS**	**NS**	**0.15**	**0.05**	**0.05**
S_1R_1	3.29	3..16	2.92	0.362	0.345	0.314	3.07	2.79	2.71
S_1R_2	3.27	3.14	2.90	0.360	0.343	0.313	3.04	2.77	2.69
S_1R_3	3.34	3.22	3.00	0.368	0.351	0.319	3.16	2.87	2.77
S_2R_1	3.28	3.14	2.91	0.361	0.344	0.314	3.05	2.78	2.69
S_2R_2	3.31	3.19	2.95	0.364	0.348	0.317	3.11	2.83	2.74
S_2R_3	3.38	3.26	3.04	0.371	0.355	0.322	3.21	2.92	2.87
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.03**	**0.03**

$H_1C_1S_1$	3.06	2.88	2.62	0.337	0.320	0.294	2.70	2.48	2.42
$H_1C_1S_2$	3.06	2.89	2.63	0.338	0.320	0.294	2.71	2.48	2.42
$H_1C_2S_1$	3.46	3.37	3.13	0.379	0.364	0.330	3.33	3.04	2.95
$H_1C_2S_2$	3.42	3.31	3.09	0.376	0.359	0.326	3.28	2.98	2.88
$H_1C_3S_1$	3.48	3.36	3.19	0.383	0.365	0.332	3.39	3.04	2.91
$H_1C_3S_2$	3.45	3.33	3.75	0.380	0.362	0.329	3.35	3.00	2.87
$H_1C_4S_1$	3.58	3.20	3.22	0.374	0.357	0.331	3.46	3.09	2.95
$H_1C_4S_2$	3.55	3.39	3.18	0.371	0.354	0.329	3.42	3.04	2.91
$H_2C_1S_1$	3.05	2.88	2.62	0.337	0.321	0.293	2.69	2.47	2.41
$H_2C_1S_2$	3.07	2.89	2.63	0.338	0.321	0.294	2.71	2.49	2.43
$H_2C_2S_1$	3.24	3.10	2.84	0.357	0.340	0.310	3.00	2.73	2.64
$H_2C_2S_2$	3.31	3.19	2.94	0.364	0.347	0.316	3.10	2.83	2.74
$H_2C_3S_1$	3.37	3.24	3.20	0.371	0.354	0.322	3.20	2.90	2.79
$H_2C_3S_2$	3.46	3.36	3.15	0.381	0.364	0.330	3.35	3.03	2.93
$H_2C_4S_1$	3.42	3.19	3.20	0.356	0.339	0.316	3.19	2.86	2.74
$H_2C_4S_2$	3.42	3.20	3.02	0.357	0.339	0.317	3.20	2.86	2.75
$H_3C_1S_1$	3.07	2.90	2.64	0.339	0.322	0.295	2.72	2.50	2.44
$H_3C_1S_2$	3.08	2.91	2.65	0.340	0.323	0.296	2.73	2.51	2.45
$H_3C_2S_1$	3.16	3.01	2.75	0.348	0.331	0.303	2.86	2.62	2.55
$H_3C_2S_2$	3.21	3.08	2.82	0.353	0.337	0.308	2.94	2.70	2.64
$H_3C_3S_1$	3.33	3.22	2.96	0.365	0.350	0.318	3.12	2.86	2.78
$H_3C_3S_2$	3.40	3.31	3.05	0.373	0.358	0.324	3.23	2.97	2.88
$H_3C_4S_1$	3.39	3.20	2.94	0.352	0.337	0.314	3.12	2.85	2.77
$H_3C_4S_2$	3.42	3.23	2.98	0.355	0.340	0.316	3.16	2.89	2.81
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_1R_1$	3.05	2.87	2.61	0.336	0.319	0.293	2.69	2.46	2.40
$H_1C_1R_2$	3.08	2.91	2.65	0.339	0.322	0.296	2.73	2.51	2.45
$H_1C_1R_3$	3.05	2.87	2.61	0.336	0.319	0.293	2.69	2.47	2.41
$H_1C_2R_1$	3.40	3.30	3.06	0.374	0.357	0.325	3.24	2.96	2.86
$H_1C_2R_2$	3.51	3.44	3.19	0.384	0.369	0.334	3.40	3.12	3.03
$H_1C_2R_3$	3.41	3.29	3.09	0.375	0.358	0.325	3.27	2.95	2.84
$H_1C_3R_1$	3.43	3.31	3.13	0.378	0.360	0.328	3.32	2.97	2.85
$H_1C_3R_2$	3.24	3.19	3.00	0.368	0.350	0.319	3.17	2.84	2.72
$H_1C_3R_3$	3.62	3.54	3.37	0.398	0.381	0.345	3.62	3.24	3.10
$H_1C_4R_1$	3.54	3.34	3.16	0.370	0.352	0.327	3.40	3.02	2.89
$H_1C_4R_2$	3.56	3.32	3.15	0.368	0.351	0.326	3.38	3.01	2.87
$H_1C_4R_3$	3.64	3.46	3.30	0.380	0.363	0.336	3.55	3.17	3.03
$H_2C_1R_1$	3.07	2.89	2.63	0.338	0.321	0.294	2.71	2.49	2.43
$H_2C_1R_2$	3.06	2.88	2.62	0.337	0.320	0.294	2.70	2.48	2.42
$H_2C_1R_3$	3.05	2.88	2.61	0.336	0.319	0.293	2.69	2.47	2.41
$H_2C_2R_1$	3.25	3.12	2.86	0.358	0.341	0.311	3.01	2.75	2.67
$H_2C_2R_2$	3.31	3.20	2.94	0.364	0.348	0.316	3.09	2.84	2.76

$H_2C_2R_3$	3.26	3.11	2.89	0.359	0.342	0.312	3.04	2.74	2.65
$H_2C_3R_1$	3.39	3.28	3.06	0.373	0.356	0.324	3.24	2.94	2.84
$H_2C_3R_2$	3.39	3.27	3.05	0.372	0.356	0.323	3.23	2.93	2.83
$H_2C_3R_3$	3.47	3.36	3.17	0.382	0.365	0.331	3.38	3.03	2.91
$H_2C_4R_1$	3.37	3.13	2.93	0.351	0.333	0.312	3.11	2.79	2.08
$H_2C_4R_2$	3.35	3.11	2.91	0.349	0.331	0.310	3.09	2.76	2.05
$H_2C_4R_3$	3.54	3.35	3.18	0.370	0.353	0.328	3.39	3.04	2.91
$H_3C_1R_1$	3.07	2.90	2.63	0.338	0.321	0.295	2.71	2.49	2.44
$H_3C_1R_2$	3.10	2.94	2.68	0.342	0.325	0.298	2.77	2.54	2.48
$H_3C_1R_3$	3.06	2.89	2.62	0.337	0.320	0.294	2.70	2.48	2.42
$H_3C_2R_1$	3.17	3.03	2.77	0.349	0.333	0.305	2.87	2.65	2.58
$H_3C_2R_2$	3.25	3.12	2.86	0.357	0.341	0.311	2.98	2.75	2.69
$H_3C_2R_3$	3.14	3.98	2.72	0.346	0.329	0.301	2.84	2.59	2.52
$H_3C_3R_1$	3.29	3.17	2.91	0.361	0.345	0.315	3.06	2.81	2.73
$H_3C_3R_2$	3.31	3.19	2.93	0.363	0.347	0.316	3.09	2.83	2.75
$H_3C_3R_3$	3.29	3.43	3.18	0.383	0.368	0.333	3.38	3.10	3.02
$H_3C_4R_1$	3.36	3.15	2.90	0.349	0.333	0.311	3.07	2.81	2.72
$H_3C_4R_2$	3.29	3.07	2.82	0.342	0.326	0.305	2.97	2.71	2.63
$H_3C_4R_3$	3.56	3.41	3.16	0.370	0.356	0.329	3.08	3.10	2.01
CD at 5%	**NS**	**0.10**	**0.08**	**NS**	**NS**	**NS**	**NS**	**0.09**	**0.09**
$H_1S_1R_1$	3.38	3.26	3.05	0.372	0.355	0.323	3.23	2.92	2.82
$H_1S_1R_2$	3.35	3.23	3.01	0.369	0.352	0.321	3.18	2.88	2.79
$H_1S_1R_3$	3.44	3.33	3.13	0.379	0.362	0.329	3.33	3.00	2.89
$H_1S_2R_1$	3.33	3.19	2.98	0.366	0.349	0.318	3.14	2.84	2.73
$H_1S_2R_2$	3.37	3.25	3.03	0.371	0.354	0.322	3.20	2.90	2.80
$H_1S_2R_3$	3.42	3.30	3.10	0.376	0.359	0.326	3.29	2.96	2.85
$H_2S_1R_1$	3.27	3.14	2.90	0.360	0.343	0.313	3.05	2.77	2.69
$H_2S_1R_2$	3.27	3.13	2.89	0.360	0.343	0.313	3.04	2.77	2.68
$H_2S_1R_3$	3.37	3.12	2.91	0.360	0.343	0.313	3.05	2.75	2.65
$H_2S_2R_1$	3.26	3.12	2.89	0.359	0.342	0.312	3.04	2.76	2.67
$H_2S_2R_2$	3.29	3.15	2.92	0.362	0.345	0.314	3.07	2.79	2.75
$H_2S_2R_3$	3.39	3.28	3.06	0.373	0.356	0.324	3.24	2.94	2.84
$H_3S_1R_1$	3.20	3.06	2.81	0.353	0.336	0.307	2.93	2.69	2.62
$H_3S_1R_2$	3.20	3.05	2.79	0.352	0.335	0.306	2.91	2.67	2.60
$H_3S_1R_3$	3.24	3.20	2.94	0.364	0.348	0.317	3.10	2.84	2.76
$H_3S_2R_1$	3.24	3.11	2..85	0.356	0.340	0.310	2.98	2.74	2.67
$H_3S_2R_2$	3.28	3.16	2.90	0.360	0.344	0.314	3.04	2.79	2.72
$H_3S_2R_3$	3.32	3.20	2.95	0.364	0.348	0.317	3.10	2.85	2.77
CD at 5%	**NS**	**0.07**	**0.06**	**NS**	**NS**	**NS**	**NS**	**0.06**	**0.06**

$C_1S_1R_1$	3.06	2.89	2.62	0.337	0.320	0.294	2.70	2.48	2.42
$C_1S_1R_2$	3.07	2.90	2.64	0.338	0.321	0.295	2.72	2.50	2.44
$C_1S_1R_3$	3.05	2.88	2.62	•0.337	0.319	0.293	2.69	2.47	2.41
$C_1S_2R_1$	3.06	2.89	2.62	0.337	0.320	0.294	2.70	2.48	2.42
$C1S_2R_2$	3.09	2.93	2.66	0.341	0.324	0.297	2.75	2.53	2.47
$C_1S_2R_3$	3.06	2.88	2.62	0.337	0.320	0.294	2.69	2.48	2.42
$C_2S_1R_1$	3.31	3.19	2.94	0.364	0.348	0.317	3.10	2.84	2.76
$C_2S_1R_2$	3.29	3.17	2.92	0.362	0.346	0.315	3.04	2.81	2.74
$C_2S_1R_3$	3.26	3.11	2.88	0.359	0.341	0.312	3.03	2.74	2.65
$C_2S_2R_1$	3.24	3.10	2.86	0.356	0.340	0.310	2.99	2.73	2.66
$C_2S_2R_2$	3.42	3.33	3.08	0.375	0.360	0.326	3.25	3.00	2.92
$C_2S_2R_3$	3.28	3.14	2.91	0.361	0.344	0.314	3.07	2.78	2.68
$C_3S_1R_1$	3.34	3.21	2.99	0.367	0.350	0.319	3.15	2.85	2.75
$C_3S_1R_2$	3.34	3.21	2.99	0.367	0.350	0.319	3.15	2.86	2.76
$C_3S_1R_3$	3.50	3.41	3.21	0.385	0.368	0.334	3.42	3.09	2.97
$C_3S_2R_1$	3.41	3.30	3.08	0.374	0.358	0.325	3.26	2.96	2.86
C_3S2R2	3.35	3.22	3.00	0.369	0.351	0.320	3.17	2.87	2.77
$C_3S_2R_3$	3.56	3.48	3.27	0.391	0.374	0.339	3.50	3.17	2.05
$C_4S_1R_1$	3.44	3.24	3.02	0.359	0.342	0.318	3.22	2.90	2.80
$C_4S_1R_2$	3.39	3.17	2.96	0.353	0.336	0.314	3.15	2.83	2.72
$C_4S_1R_3$	3.56	3.38	3.18	0.371	0.354	0.319	3.40	3.07	2.95
$C_4S_2R_1$	3.40	3.18	2.97	0.354	0.337	0.315	3.16	2.84	2.73
$C_4S_2R_2$	3.39	3.16	2.96	0.353	0.335	0.313	3.14	2.82	2.71
$C_4S_2R_3$	3.61	3.44	3.25	0.376	0.360	0.333	3.98	3.14	3.02
CD at 5%	**NS**	**0.08**	**0.08**	**NS**	**NS**	**NS**	**NS**	**0.07**	**0.07**
$H_1C_1S_1R_1$	3.11	2.94	2.68	0.342	0.325	0.298	2.77	2.54	2.48
$H_1C_1S_1R_2$	3.02	2.84	2.58	0.333	0.316	0.291	2.64	2.43	2.37
$H_1C_1S_1R_3$	3.04	2.86	2.60	0.336	0.318	0.292	2.68	2.46	2.40
$H_1C_1S_2R_1$	3.00	2.80	2.54	0.331	0.313	0.288	2.60	2.38	2.32
$H_1C_1S_2R_2$	3.13	2.98	2.72	0.345	0.328	0.301	2.81	2.59	2.53
$H_1C_1S_2R_3$	3.06	2.88	2.62	0.337	0.320	0.294	2.70	2.48	2.42
$H_1C_2S_1R_1$	3.50	3.42	3.17	0.383	0.368	0.333	3.39	3.10	3.01
$H_1C_2S_1R_2$	3.44	3.36	3.11	0.377	0.362	0.328	3.29	3.03	2.95
$H_1C_2S_1R_3$	3.44	3.33	3.12	0.378	0.361	0.328	3.31	3.00	2.89
$H_1C_2S_2R_1$	3.30	3.17	2.94	0.364	0.347	0.316	3.10	2.81	2.72
$H_1C_2S_2R_2$	3.57	3.52	3.28	0.391	0.377	0.340	3.50	3.22	3.12
$H_1C_2S_2R_3$	3.38	3.24	3.06	0.372	0.354	0.322	3.23	2.90	2.79
$H_1C_3S_1R_1$	3.42	3.29	3.11	0.377	0.359	0.327	3.30	2.96	2.84
$H_1C_3S_1R_2$	3.37	3.24	3.05	0.371	0.354	0.322	3.22	2.89	2.78
$H_1C_3S_1R_3$	3.64	3.56	3.39	0.400	0.383	0.346	3.64	3.26	3.13
$H_1C_3S_2R_1$	3.44	3.32	3.14	0.379	0.361	0.328	3.34	2.99	2.86
$H_1C_3S_2R_2$	3.30	3.14	2.95	0.364	0.346	0.316	3.12	2.78	2.66

$H_1C_3S_2R_3$	3.61	3.52	3.36	0.397	0.380	0.344	3.60	3.22	3.08
$H_1C_4S_1R_1$	3.51	3.30	3.13	0.367	0.349	0.325	3.35	2.98	2.85
$H_1C_4S_1R_2$	3.58	3.39	3.22	0.374	0.357	0.331	3.47	3.09	2.95
$H_1C_4S_1R_3$	3.66	3.49	3.22	0.382	0.365	0.338	3.57	3.20	3.06
$H_1C_4S_2R_1$	3.57	3.37	3.20	0.373	0.355	0.330	3.44	3.06	2.92
$H_1C_4S_2R_2$	3.47	3.25	3.07	0.362	0.344	0.321	3.29	2.92	3.79
$H_1C_4S_2R_3$	3.62	3.44	3.27	0.375	0.369	0.335	3.52	3.14	3.01
$H_2C_1S_1R_1$	3.05	2.87	2.61	0.336	0.319	0.293	2.68	2.47	2.41
$H_2C_1S_1R_2$	3.11	2.95	2.69	0.343	0.326	0.298	2.78	2.55	2.49
$H_2C_1S_1R_3$	3.00	2.81	2.55	0.331	0.314	0.289	2.61	2.40	2.34
$H_2C_1S_2R_1$	3.08	2.91	2.65	0.339	0.322	0.296	2.73	2.51	2.45
$H_2C_1S_2R_2$	3.01	2.82	2.56	0.332	0.315	0.290	2.63	2.41	2.35
$H_2C_1S_2R_3$	3.10	2.94	2.68	0.342	0.325	0.298	2.76	2.54	2.48
$H_2C_2S_1R_1$	3.31	3.18	2.93	0.363	0.347	0.316	3.09	2.83	2.74
$H_2C_2S_1R_2$	3.23	3.10	2.84	0.355	0.339	0.309	2.97	2.73	2.65
$H_2C_2S_1R_3$	3.19	3.01	2.80	0.352	0.333	0.305	2.93	2.63	2.53
$H_2C_2S_2R_1$	3.20	3.05	2.80	0.353	336	0.307	2.93	2.68	2.60
$H_2C_2S_2R_2$	3.39	3.29	3.04	0.372	0.356	0.323	3.21	2.95	2.87
$H_2C_2S_2R_3$	3.34	3.21	2.97	0.367	0.350	0.319	3.15	2.86	2.76
$H_2C_3S_1R_1$	3.29	3.15	2.93	0.363	0.345	0.315	3.09	2.79	2.69
$H_2C_3S_1R_2$	3.41	3.31	3.08	0.375	0.359	0.326	3.26	2.97	2.87
$H_2C_3S_1R_3$	3.41	3.28	3.10	0.375	0.357	0.325	3.28	2.94	2.82
$H_2C_3S_2R_1$	3.49	3.41	3.19	0.383	0.368	0.333	3.39	3.09	2.98
$H_2C_3S_2R_2$	3.36	3.24	3.01	0.370	0.353	0.321	3.19	2.89	2.79
$H_2C_3S_2R_3$	3.53	3.44	3.24	0.388	0.372	0.337	3.47	3.13	3.01
$H_2C_4S_1R_1$	3.45	3.24	3.03	0.359	0.343	0.319	3.24	2.92	2.80
$H_2C_4S_1R_2$	3.31	3.07	2.85	0.345	0.327	0.307	3.03	2.71	2.61
$H_2C_4S_1R_3$	3.48	3.27	3.10	0.363	0.346	0.322	3.30	2.95	2.82
$H_2C_4S_2R_1$	3.28	3.02	2.83	0.342	0.324	0.304	2.99	2.66	2.55
$H_2C_4S_2R_2$	3.38	3.15	2.97	0.353	0.335	0.313	3.15	2.81	2.69
$H_2C_4S_2R_3$	3.60	3.543	3.26	0.376	0.359	0.323	3.48	3.13	3.00
$H_3C_1S_1R_1$	3.03	2.85	2.58	0.334	0.317	0.291	2.65	2.44	2.38
$H_3C_1S_1R_2$	3.08	2.90	2.64	0.339	0.322	0.295	2.72	2.50	2.44
$H_3C_1S_1R_3$	3.12	2.95	2.69	0.343	0.326	0.299	2.79	2.56	2.50
$H_3C_1S_2R_1$	3.11	2.95	2.68	0.342	0.325	0.298	2.77	2.55	2.49
$H_3C_1S_2R_2$	3.13	2.97	2.71	0.345	0.328	0.300	2.81	2.58	2.52
$H_3C_1S_2R_3$	3.01	2.82	2.56	0.332	0.314	0.289	2.62	2.41	2.35
$H_3C_2S_1R_1$	3.13	2.97	2.71	0.345	0.328	0.300	2.81	2.58	2.52
$H_3C_2S_1R_2$	3.20	3.06	2.80	0.352	0.336	0.306	2.92	2.68	2.62
$H_3C_2S_1R_3$	3.15	2.99	2.73	0.347	0.330	0.302	2.84	2.60	2.53
$H_3C_2S_2R_1$	3.21	3.06	2.83	0.353	0.337	0.308	2.93	2.71	2.65
$H_3C_2S_2R_2$	3.29	3.18	2.92	0.361	0.346	0.315	3.05	2.82	2.76

$H_3C_2S_2R_3$	3.14	2.97	2.71	0.346	0.328	0.301	2.83	2.58	2.50
$H_3C_3S_1R_1$	3.29	3.17	2.92	0.362	0.346	0.315	3.07	2.81	2.74
$H_3C_3S_1R_2$	3.23	3.09	2.83	0.355	0.338	0.309	2.96	2.72	2.64
$H_3C_3S_1R_3$	3.46	3.38	3.13	0.379	0.364	0.330	3.32	3.05	2.97
$H_3C_3S_2R_1$	3.28	3.16	2.91	0.361	0.345	0.314	3.05	2.80	2.73
$H_3C_3S_2R_2$	3.39	3.29	3.04	0.372	0.356	0.323	3.21	2.95	2.86
$H_3C_3S_2R_3$	3.53	3.47	3.22	0.386	0.372	0.336	3.43	3.15	3.07
$H_3C_4S_1R_1$	3.36	3.26	2.91	0.349	0.334	0.311	3.08	2.81	2.73
$H_3C_4S_1R_2$	3.28	3.06	2.80	0.341	0.325	0.304	2.95	2.69	2.62
$H_3C_4S_1R_3$	3.53	3.37	3.12	0.366	0.352	0.326	3.33	3.05	2.966
$H_3C_4S_2R_1$	3.35	3.15	2.89	0.348	0.333	0.310	3.06	2.80	2.72
$H_3C_4S_2R_2$	3.31	3.08	2.83	0.343	0.327	0.306	2.99	2.73	2.64
$H_3C_4S_2R_3$	3.39	3.46	3.21	0.373	0.359	0.332	3.43	3.15	3.06
CD at 5%	**NS**	**0.15**	**0.13**	**NS**	**NS**	**NS**	**NS**	**0.13**	**0.13**

GA_3 at 7 and 14 days, after the emergence of the plumule, possessed largest quantity of N and P.

4.4.10 Shoot length per plant

Table 25 reveals that the shoot length was significantly enhanced by the treatment. GA_3 (H_1) was very prominent in its effect, generating the values far superior than the other hormones (H_2 and H_3). It was followed by IAA (H_2). Considering the hormonal level, the two higher concentrations (C_3 and C_4) made a significant comparable impact. The soaking durations were non-significant. Application of hormones, two times (R_3), was significantly superior than single (R_1 or R_2) application.

Two and three factor interactions were largely significant. The shoot length interacted to the best extent, with the combinations H_1C_3, H_1C_4, H_1R_3, C_4S_1, C_3R_3, S_2R_3 and $H_1C_3R_3$ and $C_3S_2R_3$, at 25 and 35 DAS, respectively.

4.4.11 Shoot fresh weight per plant

Fresh weight of the shoot was significantly increased, over the control, by the treatment (Table 25). A maximum increase was recorded in GA_3 (H_1) which was followed by the auxins (H_2 and H_3, in that order). Throughout the study, the medium level 10^{-7}M (C_3) of the hormones proved significantly superior than others (C_4 and C_2). The soaking periods differed non-significantly. The plants gave significantly superior response to repeated application (R_3) than single applications (R_1 or R_2).

The two and three factor interactions were significant, at most of the stages of growth, where H_1C_3 (at all the stages of growth), H_1R_3 and

C_3R_3 (at 25 and 45 DAS) and S_2R_3 (only at 25 DAS) were best. Similarly, $H_1C_3R_3$ gave superior, significant impact, at 25 DAS.

4.4.12 Shoot dry weight per plant

Shoot dry weight, like its fresh weight, was significantly enhanced by the treatment (Table 25), where GA_3 (H_1) was significantly superior over the other two hormones (H_2 and H_3). The plants treated with $10^{-7}M$ (C_3) possessed the highest values but were comparable with that of C_4, at 35 DAS. Soaking hours did not show any significant impact on shoot dry weight. Application of the hormones, two times (R_3) proved best than R_1 or R_2. Regarding the interaction effect, the best two factor combinations are H_1C_3. H_1C_4 and C_3R_3, at all the stages of growth and H_1R_3. S_2R_3 only, at 25 and 35 DAS. The three and four factor interactions were significant only, at the early stage of growth (25 DAS) and the best combinations are $H_1C_3R_3$ and $H_1C_3S_1R_3$, respectively.

4.4.13 Leaf number per plant

It is evident from table 26 that the plants raised with the exogenously applied hormones possessed more leaves than the control, at all the stages of growth, studied. IAA (H_2) induced maximum increase, followed by GA_3 (H_1) and IBA (H_3). A linear increase in leaf number was recorded with the increase in the concentration of the hormones. The two higher concentrations (C_3 and C_4) proved best and were at par in their effect. Repeated application (R_3) of the hormones gave the best response, but it was at par with its single applications (R_1 or R_2) at 35 and 45 DAS.

Leaf number interacted significantly with some of the treatment variants and gave maximum values with H_2C_4, C_3R_3 and $H_2C_4S_1$ combinations.

Table 25. The length (cm), fresh and dry weight (g) of the shoot of the plants, received water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M of GA_3 (H_1), IAA (H_2) or IBA (H_3) through seeds for 12 (S_1) or 18 (S_2) hours and with nutrient solution on 7th (R_1) or 14th (R_2) or both 7th and 14th (R_3) days, after the emergence of the seedlings. The sampling was done at 25, 35 and 45 days after sowing.

Treatments	Length			Fresh weight			Dry weight		
	DAYS AFTER SOWING								
	25	35	45	25	35	45	25	35	45
H_1	14.06	23.93	41.80	1.296	1.894	2.322	0.310	0.452	1.894
H_2	12.99	22.37	38.89	1.191	1.726	2.124	0.284	0.425	1.715
H_3	11.20	17.93	32.04	1.048	1.498	1.838	0.246	0.380	1.498
CD at 5%	**0.17**	**0.31**	**0.68**	**0.014**	**0.038**	**0.032**	**0.003**	**0.006**	**0.043**
C_1	9.32	17.11	29.08	0.916	0.285	1.594	0.221	0.333	1.270
C_2	12.01	20.67	35.95	1.120	1.612	1.981	0.266	0.400	1.612
C_3	14.25	22.89	40.85	1.301	1.901	2.328	0.309	0.456	1.901
C_4	14.42	22.96	40.43	1.278	1.825	2.276	0.305	0.456	1.825
CD at 5%	**0.29**	**0.36**	**0.78**	**0.016**	**0.044**	0.037	**0.003**	**0.007**	**0.050**
S_1	12.70	21.42	37.53	1.172	1.695	2.082	0.279	0.417	1.687
S_2	12.80	21.40	37.62	1.186	1.717	2.107	0.282	0.420	1.717
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
R_1	12.59	21.36	37.35	1.156	1.670	2.053	0.275	0.415	1.658
R_2	12.34	20.71	36.36	1..146	1..654	2.033	0.273	0.409	1.654
R_3	13.32	22.16	39.02	1.234	1.794	2.198	0.293	0.433	1.794
CD at 5%	**0.17**	**0.31**	**0.68**	**0.014**	**0.038**	**0.032**	**0.003**	**0.006**	**0.043**
H_1C_1	9.36	17.60	29.65	0.916	1.285	1.394	0.220	0.334	1.285
H_1C_2	13.18	22.94	39.73	1.234	1.794	2.197	0.294	0.430	1.794
H_1C_3	16.11	26.37	46.73	1.467	2.167	2.653	0.352	0.503	2.167
H_1C_4	16.61	26.82	46.07	1.468	2.129	2.615	0.353	0.510	2.129
H_2C_1	9.28	17.08	28.99	0.912	1.280	1.588	0.220	0.339	1.234
H_2C_2	12.38	21.53	37.30	1.129	1.626	2.088	0.270	0.409	1.626
H_2C_3	14.53	24.13	42.52	1.318	1.929	2.366	0.314	0.463	1.929
H_2C_4	14.77	24.73	43.75	1.106	1.870	2.334	0.314	0.464	1.870
H_3C_1	9.33	16.67	28.59	0.920	1.291	1.600	0.221	0.333	1.291
H_3C_2	10.47	17.54	30.81	0.996	1.414	1.734	0.234	0.362	1.414
H_3C_3	12.11	18.16	33.30	1.117	1.607	1.966	0.261	0.403	1.607
H_3C_4	11.89	17.34	32.45	0.861	1.477	1.847	0.249	0.392	1.477
CD at 5%	**0.34**	**0.63**	**1.36**	**0.028**	**0.076**	**0.064**	**0.006**	**0.012**	**0.087**
H_1S_1	13.94	23.82	41.54	1.290	1.884	2.309	0.308	0.449	1.884
H_1S_2	14.19	24.04	42.05	1.302	1.903	2.336	0.312	0.455	1.903
H_2S_1	12.95	22.39	38.77	1.182	1.711	2.109	0.283	0.424	1.688
H_2S_2	13.03	22.44	39.02	1.201	1.742	2.139	0.286	0.426	1.742
H_3S_1	11.20	18.15	32.29	1.043	1..488	1.829	0.245	0.380	1.488
H_3S_2	11.19	17.71	31.79	1.054	1.507	1.829	0.247	0.380	1.507
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

H_1R_1	13.84	23.76	41.36	1.274	1.858	2.287	0.307	0.446	1.858
H_1R_2	13.48	22.97	40.09	1.250	1.820	2.232	0.299	0.437	1.820
H_1R_3	14.88	25.06	43.93	1.364	2.003	2.447	0.324	0.472	2.003
H_2R_1	12.85	22.30	38.66	1.163	1.680	2.071	0.277	0.421	1.646
H_2R_2	12.50	21.59	37.50	1.152	1.664	2.050	0.276	0.413	1.664
H_2R_3	13.62	23.21	40.51	1.259	1.835	2.252	0.301	0.441	1.835
H_3R_1	11.08	18.02	32.93	1.032	1.470	1.802	0.241	0.377	1.470
H_3R_2	11.05	17.56	31.47	1..036	1.478	1.816	0.244	0.376	1.478
H_3R_3	11.46	18.19	32.62	1.078	1.544	1.895	0.254	0.387	1.544
CD at 5%	**0.29**	**0.54**	**1.18**	**0.02**	**NS**	**0.056**	**0.005**	**0.010**	**NS**
C_1S_1	9.34	17.07	29.06	0.915	1.284	1.592	0.220	0.334	1.254
C_1S_2	9.30	17.15	29.10	0.916	1.286	1.595	0.221	0.333	1.286
C_2S_1	11.92	21.12	36.34	1.111	1.597	1.966	0.265	0.398	1.597
C_2S_2	12.10	20.22	35.55	1.129	1.626	1.995	0.267	0.403	1.626
C_3S_1	14.14	22.66	40.48	1.292	1.887	2.310	0.306	0.454	1.887
C_3S_2	14.36	23.12	41.22	1.310	1.915	2.347	0.312	0.459	1.915
C_4S_1	14.39	23.83	39.25	1.269	1.810	2.260	0.303	0.455	1.801
C_4S_2	14.45	23.09	39.60	1.288	1.841	2.292	0.307	0.456	1.841
CD at 5%	**NS**	**0.51**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
C_1R_1	9.30	17.23	29.18	0.914	1.282	1.591	0.221	0.332	1.236
C_1R_2	9.35	17.10	29.09	0.922	1.295	1.605	0.222	0.334	1.295
C_1R_3	9.31	17.01	28.96	0.912	1.279	1.586	0.219	0.333	1.279
C_2R_1	11.83	21.10	36.22	1.090	1.564	1.924	0.258	0.396	1.564
C_2R_2	11.05	18.89	32.93	1.072	1.535	1.877	0.253	0.376	1.535
C_2R_3	13.15	22.03	38.70	1.197	1.736	2.141	0.287	0.429	1.736
C_3R_1	13.91	22.29	39.82	1.266	1.846	2.262	0.300	0.448	1.846
C_3R_2	13.41	21.68	38.60	1.236	1.798	2.210	0.296	0.435	1.798
C_3R_3	15.43	24.70	44.13	1.400	2.060	2.513	0.331	0.486	2.060
C_4R_1	14.32	22.83	39.16	1.254	1.787	2.236	0.300	0.453	1.787
C_4R_2	14.56	23.17	39.80	1.255	1.788	2.239	0.300	0.459	1.788
C_4R_3	14.39	22.89	39.31	1.325	1.901	2.352	0.316	0.455	1.901
CD at 5%	**0.33**	**0.62**	**1.35**	**0.028**	**NS**	**0.064**	**0.006**	**0.012**	**0.087**
S_1R_1	12.67	21.47	37.55	1.156	1.669	2.054	0.275	0.417	1.646
S_1R_2	12.13	20.52	35.92	1.129	1.627	2.001	0.269	0.403	1.627
S_1R_3	13.29	22.27	39.12	1.230	1.788	2.192	0.293	0.432	1.788
S_2R_1	12.51	21.25	37.14	1.157	1.670	2.053	0.275	0.413	1.670
S_2R_2	12.55	20.89	36.75	1.163	1.681	2.065	0.277	0.414	1.681
S_2R_3	13.35	22.04	38.92	1.237	1.800	2.204	0.294	0.434	1.800
CD at 5%	**0.23**	**NS**	**NS**	**0.020**	**NS**	**NS**	**0.004**	**0.008**	**NS**
$H_1C_1S_1$	9.41	17.55	29.66	0.917	1.287	1.595	0.220	0.335	1.287
$H_1C_1S_2$	9.31	17.65	29.65	0.915	1.283	1.593	0.221	0.333	1.283
$H_1C_2S_1$	12.85	22.95	39.37	1.209	1.755	2.150	0.288	0.421	1.755
$H_1C_2S_2$	13.51	22.93	40.09	1,259	1.834	2.244	0.299	0.438	1.834
$H_1C_3S_1$	15.91	26.07	46.18	1.462	2.160	2.639	0.350	0.498	2.160
$H_1C_3S_2$	16.30	26.68	47.28	1.471	2.173	2.667	0.354	0.508	2.173

$H_1C_4S_1$	15.59	26.73	45.96	1.473	2.136	2.651	0.354	0.510	2.136
$H_1C_4S_2$	16.63	26.91	46.91	1.463	2.121	2.639	0.353	0.511	2.121
$H_2C_1S_1$	9.29	17.05	28.98	0.911	1.278	1.586	0.220	0.332	1.186
$H_2C_1S_2$	9.27	17.10	29.01	0.914	1.282	1.590	0.221	0.332	1.282
$H_2C_2S_1$	12.31	21.80	37.52	1.128	1.625	2.009	0.271	0.408	1.625
$H_2C_2S_2$	12.44	21.27	37.09	1.129	1.627	2.007	0.269	0.411	1.627
$H_2C_3S_1$	14.50	23.88	42.22	1.311	1.917	2.350	0.311	0.462	1.917
$H_2C_3S_2$	14.56	24.37	42.82	1.326	1.941	2.382	0.317	0.464	1.941
$H_2C_4S_1$	16.70	24.46	41.36	1.278	2.824	2.291	0.309	0.463	1.824
$H_2C_4S_2$	16.84	25.02	42.15	1.335	1.916	2.378	0.319	0.466	1.916
$H_3C_1S_1$	9.32	16.62	28.53	0.918	1.289	1.597	0.221	0.333	1.289
$H_3C_1S_2$	9.33	16.71	28.65	0.921	1.294	1.602	0.222	0.333	1.294
$H_3C_2S_1$	10.59	18.62	32.14	0.995	1.411	1.740	0.235	0.365	1.411
$H_3C_2S_2$	10.35	16.46	29.49	0.998	1.418	1.734	0.233	0.359	1.418
$H_3C_3S_1$	12.02	18.02	33.04	1.102	1.584	1.940	0.258	0.400	1.584
$H_3C_3S_2$	12.20	18.30	33.56	1.132	1.631	1.992	0.264	0.405	1.631
$H_3C_4S_1$	11.89	17.33	30.43	1.056	1.469	1.837	0.247	0.392	1.469
$H_3C_4S_2$	11.90	17.34	30.46	1.066	1.485	1.858	0.250	0.392	1.485
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_1R_1$	9.50	17.99	30.24	0.920	1.611	1.611	0.224	0.337	1.292
$H_1C_1R_2$	9.07	17.07	28.76	0.909	1.574	1.574	0.218	0.327	1.274
$H_1C_1R_3$	9.51	17.73	29.97	0.918	1.596	1.596	0.219	0.338	1.289
$H_1C_2R_1$	13.02	23.26	39.90	1.197	2.137	2.137	0.287	0.425	1.735
$H_1C_2R_2$	12.02	20.91	36.22	1.159	2.043	2.043	0.274	0.400	1.674
$H_1C_2R_3$	14.51	24.64	43.07	1.346	2.410	2.410	0.320	0.463	1.974
$H_1C_3R_1$	15.43	25.28	44.78	1.428	2.582	2.582	0.346	0.486	2.105
$H_1C_3R_2$	15.02	24.77	43.77	1.374	2.481	2.481	0.332	0.476	2.018
$H_1C_3R_3$	17.87	29.07	51.64	1.598	2.896	2.896	0.379	0.547	2.377
$H_1C_4R_1$	16.42	26.52	45.53	1.451	2.619	2.619	0.352	0.505	2.101
$H_1C_4R_2$	16.80	27.41	46.63	1.459	2.630	2.630	0.350	0.515	2.115
$H_1C_4R_3$	16.61	26.81	46.06	1.494	2.686	2.686	0.359	0.510	2.171
$H_2C_1R_1$	9.10	16.99	28.69	0.907	1.271	1.578	0.220	0.327	1.133
$H_2C_1R_2$	9.52	17.40	29.61	0.923	1.297	1.613	0.223	0.328	1.297
$H_2C_1R_3$	9.22	16.85	28.68	0.907	1.271	1.573	0.217	0.331	1.271
$H_2C_2R_1$	12.27	21.88	37.57	1.095	1.572	1.947	0.261	0.407	1.572
$H_2C_2R_2$	11.28	19.63	34.01	1.069	1.531	1.881	0.254	0.382	1.531
$H_2C_2R_3$	13.58	23.08	40.34	1.222	1.775	2.197	0.295	0.440	1.775
$H_2C_3R_1$	14.34	23.67	41.81	1.282	1.872	2.294	0.303	0.459	1.872
$H_2C_3R_2$	13.42	22.57	39.58	1.245	1.812	2.227	0.299	0.435	1.812
$H_2C_3R_3$	15.82	26.14	46.16	1.427	2.103	2.577	0.341	0.496	2.103
$H_2C_4R_1$	14.68	24.67	41.59	1.266	1.806	2.264	0.303	0.462	1.806
$H_2C_4R_2$	14.78	24.75	41.79	1.271	2.814	2.280	0.307	0.465	2.814
$H_2C_4R_3$	14.85	24.77	41.88	1.382	2.991	2.459	0.331	0.466	2.991
$H_3C_1R_1$	9.30	16.72	28.63	0.914	1.283	1.585	0.218	0.333	1.283
$H_3C_1R_2$	9.46	16.82	28.92	0.933	1.313	1.627	0.225	0.337	1.313

$H_3C_1R_3$	9.21	16.46	28.23	0.911	1.278	1.587	0.221	0.330	1.278
$H_3C_2R_1$	10.22	18.15	31.20	0.978	1.385	1.688	0.225	0.355	1.385
$H_3C_2R_2$	9.85	16.12	28.56	0.988	1.400	1.707	0.232	0.346	1.400
$H_3C_2R_3$	11.34	18.37	32.68	1.024	1.458	1.816	0.246	0.384	1.458
$H_3C_3R_1$	11.95	17.93	32.87	1.087	1.560	1.911	0.253	0.399	1.560
$H_3C_3R_2$	11.79	17.69	32.43	1.089	1.562	1.921	0.257	0.395	1.562
$H_3C_3R_3$	12.58	18.88	34.61	1.175	1.700	2.066	0.273	0.415	1.700
$H_3C_4R_1$	11.86	17.30	30.38	1.046	1.454	1.826	0.246	0.392	1.454
$H_3C_4R_2$	12.09	17.63	30.99	1.035	1.436	2.808	0.242	0.397	1.436
$H_3C_4R_3$	11.72	17.08	29.98	1.100	1.541	1.909	0.198	0.388	1.541
CD at 5%	**0.58**	**NS**	**NS**	**0.049**	**NS**	**NS**	**0.010**	**NS**	**NS**
$H_1S_1R_1$	13.90	23.87	41.56	1.277	1.863	2.289	0.306	0.448	1.863
$H_1S_1R_2$	13.22	22.70	39.52	1.239	1.803	2.209	0.296	0.431	1.803
$H_1S_1R_3$	14.79	24.89	43.55	1.355	1.988	2.429	0.322	0.467	1.988
$H_1S_2R_1$	13.78	23.65	41.17	1.271	1.854	2.286	0.308	0.444	1.854
$H_1S_2R_2$	13.73	23.24	40.67	1.261	1.838	2.255	0.301	0.443	1.838
$H_1S_2R_3$	15.06	25.23	44.32	1.374	1.018	2.466	0.326	0.426	2.018
$H_2S_1R_1$	12.95	22.42	38.91	1.160	1.676	2.069	0.276	0.424	1.607
$H_2S_1R_2$	12.30	21.25	36.91	1.132	1.630	2.012	0.271	0.408	1.630
$H_2S_1R_3$	13.60	23.21	40.49	1.254	1.827	2.246	0.301	0.440	1.827
$H_2S_2R_1$	12.74	22.18	38.42	1.165	1.685	2.073	0.277	0.419	1.685
$H_2S_2R_2$	12.70	21.93	38.09	1.173	1.697	2.088	0.280	0.417	1.697
$H_2S_2R_3$	13.64	23.20	40.54	1.265	1.843	2.257	0.301	0.441	1.843
$H_3S_1R_1$	11.15	18.41	32.19	1.030	1.468	1.805	0.342	0.379	1.468
$H_3S_1R_2$	10.87	17.62	31.34	1.017	1.447	1.781	0.240	0.372	1.447
$H_3S_1R_3$	11.59	18.72	33.34	1.018	1.550	1.901	0.254	0.390	1.550
$H_3S_2R_1$	11.02	17.93	31.85	1.033	1.473	1.800	0.240	0.376	1.473
$H_3S_2R_2$	11.22	17.51	31.61	1.056	1.509	1.851	0.248	0.381	1.509
$H_3S_2R_3$	11.34	17.67	31.91	1.074	1.538	1.889	0.255	0.384	1.538
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$C_1S_1R_1$	9.35	17.30	29.31	0.915	1.284	1.592	0.220	0.334	1.192
$C_1S_1R_2$	9.26	16.87	28.75	0.915	1.284	1.592	0.221	0.332	1.284
$C_1S_1R_3$	9.41	17.05	29.10	0.916	1.285	1.593	0.220	0.335	1.285
$C_1S_2R_1$	9.25	17.16	29.05	0.912	1.280	1.590	0.221	0.331	1.280
$C_1S_2R_2$	9.44	17.32	29.44	0.929	1.306	1.617	0.224	0.336	1.306
$C_1S_2R_3$	9.22	16.98	28.82	0.908	1.273	1.578	0.218	0.331	1.273
$C_2S_1R_1$	11.90	21.17	36.38	1.097	1.575	1.942	0.261	0.397	1.575
$C_2S_1R_2$	10.85	19.48	33.34	1.045	1.492	1.830	0.247	0.371	1.492
$C_2S_1R_3$	13.01	22.73	39.31	1.190	1.725	2.127	0.286	0.425	1.725
$C_2S_2R_1$	11.77	21.02	36.07	1.083	1.553	1.906	0.254	0.394	1.553
$C_2S_2R_2$	11.25	18.31	32.52	1.099	1.578	1.924	0.259	0.381	1.578
$C_2S_2R_3$	13.29	21.33	38.08	1.204	1.747	2.155	0.289	0.332	1.747
$C_3S_1R_1$	14.09	22.58	40.34	1.262	1.840	2.259	0.299	0.452	1.840
$C_3S_1R_2$	12.99	20.90	37.28	1.216	1.766	2.167	0.291	0.425	1.766
$C_3S_1R_3$	15.35	24.49	43.82	1.397	2.054	2.504	0.329	0.484	2.054

$C_3S_2R_1$	13.73	22.00	39.30	1.270	1.851	2.266	0.302	0.443	1.851
$C_3S_2R_2$	13.83	22.45	39.91	1.255	1.829	2.253	0.301	0.446	1.829
$C_3S_2R_3$	15.50	24.90	44.44	1.404	2.066	2.522	0.332	0.488	2.066
$C_4S_1R_1$	14.33	22.82	39.17	1.248	1.777	2.223	0.298	0.453	1.777
$C_4S_1R_2$	14.43	22.86	39.22	1.240	1.764	2.214	0.297	0.456	1.764
$C_4S_1R_3$	14.41	22.83	39.26	1.318	1.889	2.342	0.315	0.455	1.889
$C_4S_2R_1$	14.51	22.84	39.16	1.261	1.797	2.249	0.303	0.453	1.797
$C_4S_2R_2$	14.68	23.49	40.29	1.270	2.812	2.265	0.302	0.462	2.812
$C_4S_2R_3$	14.38	22.95	39.36	1.333	1.913	2.361	0.317	0.454	1.913
CD at 5%	**NS**	**0.88**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_1S_1R_1$	9.71	18.30	30.81	0.944	1.331	1.649	0.227	0.343	1.331
$H_1C_1S_1R_2$	8.94	16.74	28.25	0.888	1.240	1.540	0.214	0.324	1.240
$H_1C_1S_1R_3$	9.58	17.60	29.91	0.918	1.289	1.596	0.218	0.340	1.289
$H_1C_1S_2R_1$	9.28	17.69	29.66	0.898	1.254	1.573	0.221	0.332	1.254
$H_1C_1S_2R_2$	9.20	17.40	29.26	0.930	1.307	1.608	0.222	0.330	1.307
$H_1C_1S_2R_3$	9.44	17.86	30.04	0.918	1.289	1.597	0.220	0.336	1.289
$H_1C_2S_1R_1$	12.90	23.10	39.59	1.196	1.734	2.134	0.287	0.422	1.734
$H_1C_2S_1R_2$	11.63	21.11	36.01	1.122	1.615	1.969	0.264	0.391	1.615
$H_1C_2S_1R_3$	14.02	24.63	42.51	1.310	1.916	2.346	0.314	0.450	1.919
$H_1C_2S_2R_1$	13.14	23.42	40.22	1.198	1.736	2.140	0.287	0.428	1.736
$H_1C_2S_2R_2$	12.40	20.71	36.42	1.196	1.734	2.117	0.285	0.410	0.734
$H_1C_2S_2R_3$	15.01	24.65	43.63	1.382	2.031	2.474	0.326	0.475	2.031
$H_1C_3S_1R_1$	15.65	25.66	45.44	1.431	2.110	2.585	0.344	0.491	2.110
$H_1C_3S_1R_2$	14.54	23.99	42.36	1.366	2.005	2.454	0.329	0.464	2.005
$H_1C_3S_1R_3$	17.56	28.55	50.72	1.590	2.365	2.879	0.378	0.539	2.365
$H_1C_3S_2R_1$	15.22	24.89	44.12	1.425	2.099	2.579	0.348	0.480	2.099
$H_1C_3S_2R_2$	15.50	25.55	45.16	1.382	2.031	2.509	0.336	0.458	2.031
$H_1C_3S_2R_3$	18.19	29.59	52.56	1.606	2.300	2.913	0.380	0.555	2.390
$H_1C_4S_1R_1$	16.36	26.44	45.38	1.436	2.078	2.587	0.346	0.504	2.078
$H_1C_4S_1R_2$	16.78	26.97	46.42	1.482	2.151	2.673	0.357	0.514	2.151
$H_1C_4S_1R_3$	16.63	26.79	46.06	1.501	2.181	2.694	0.579	0.511	2.181
$H_1C_4S_2R_1$	16.47	26.60	45.68	1.465	2.125	2.650	0.357	0.507	2.125
$H_1C_4S_2R_2$	16.82	27.30	46.84	1.437	2.079	2.587	0.342	0.516	2.079
$H_1C_4S_2R_3$	16.58	26.84	46.06	1.488	2.161	2.679	0.359	0.510	2.161
$H_2C_1S_1R_1$	9.07	16.97	28.64	0.901	1.262	1.569	0.219	0.327	0.986
$H_2C_1S_1R_2$	9.62	17.47	29.80	0.941	1.326	1.639	0.226	0.340	1.326
$H_2C_1S_1R_3$	9.18	16.71	28.49	0.891	1.245	1.548	0.214	0.330	1.245
$H_2C_1S_2R_1$	9.12	17.01	28.74	0.913	1.280	1.587	0.221	0.328	1.280
$H_2C_1S_2R_2$	9.42	17.32	29.42	0.906	1.269	1.586	0.221	0.336	1.269
$H_2C_1S_2R_3$	9.26	16.98	28.87	0.923	1.296	1.598	0.220	0.332	1.296
$H_2C_2S_1R_1$	12.35	21.94	37.72	1.115	1.604	1.985	0.267	0.409	1.604
$H_2C_2S_1R_2$	10.96	19.66	33.68	1.034	1.474	1.819	0.247	0.374	1.474
$H_2C_2S_1R_3$	13.63	23.79	41.16	1.236	1.798	2.224	0.300	0.441	1.798
$H_2C_2S_2R_1$	12.19	21.83	37.42	1.075	1.541	1.909	0.255	0.405	1.541
$H_2C_2S_2R_2$	11.60	19.61	34.33	1.105	1.588	1.943	0.261	0.390	1.588

$H_2C_2S_2R_3$	13.54	22.38	39.51	1.208	1.752	2.170	0.291	0.438	1.752
$H_2C_3S_1R_1$	14.64	24.11	42.63	1.265	1.844	2.271	0.298	0.466	1.844
$H_2C_3S_1R_2$	12.99	21.58	38.03	1.234	1.795	2.198	0.296	0.425	1.795
$H_2C_3S_1R_3$	15.86	25.96	46.00	1.433	2.112	2.581	0.340	0.406	2.112
$H_2C_3S_2R_1$	14.05	23.22	41.00	1.300	1.900	2.318	0.307	0.451	1.900
$H_2C_3S_2R_2$	13.84	23.56	41.14	1.256	1.829	2.255	0.302	0.446	1.829
$H_2C_3S_2R_3$	15.79	26.32	46.32	1.422	2.095	2.573	0.342	0.495	2.095
$H_2C_4S_1R_1$	14.70	24.68	41.67	1.259	1.795	2.251	0.301	0.464	1.795
$H_2C_4S_1R_2$	14.65	24.28	41.12	1.217	1.727	2.191	0.295	0.461	1.727
$H_2C_4S_1R_3$	14.71	24.37	41.29	1.357	1.952	2.429	0.330	0.463	1.952
$H_2C_4S_2R_1$	14.62	24.67	41.51	1.273	1.818	2.276	0.306	0.460	1.818
$H_2C_4S_2R_2$	14.92	25.23	42.46	1.325	1.901	2.370	0.318	0.468	1.901
$H_2C_4S_2R_3$	14.98	25.17	42.47	1.406	2.030	2.489	0.332	0.470	2.030
$H_3C_1S_1R_1$	9.26	16.64	28.50	0.900	1.260	1.559	0.214	0.332	1.260
$H_3C_1S_1R_2$	9.23	16.40	28.19	0.916	1.285	1.596	0.222	0.331	1.385
$H_3C_1S_1R_3$	9.46	16.83	28.92	0.938	1.320	1.636	0.227	0.336	1.320
$H_3C_1S_2R_1$	9.34	16.80	28.76	0.928	1.305	1.611	0.222	0.334	1.305
$H_3C_1S_2R_2$	9.70	17.25	29.64	0.951	1.342	1.658	0.228	0.332	1.342
$H_3C_1S_2R_3$	9.96	16.08	27.55	0.884	1.235	1.538	0.215	0.324	1.232
$H_3C_2S_1R_1$	10.45	18.49	31.83	0.979	1.386	1.708	0.230	0.361	1.386
$H_3C_2S_1R_2$	9.95	17.62	30.33	0.980	1.388	1.702	0.232	0.340	1.388
$H_3C_2S_1R_3$	11.58	19.77	34.26	1.025	1.460	1.810	0.244	0.334	1.460
$H_3C_2S_2R_1$	9.98	17.81	30.57	0.977	1.383	1.668	0.220	0.350	1.383
$H_3C_2S_2R_2$	9.74	14.62	26.80	0.995	1.412	1.712	0.231	0.344	1.412
$H_3C_2S_2R_3$	11.31	16.97	31.11	1.023	1.457	1.821	0.249	0.383	1.457
$H_3C_3S_1R_1$	11.98	17.98	32.96	1.091	1.566	1.921	0.255	0.400	1.566
$H_3C_3S_1R_2$	11.42	17.14	31.42	1.050	1.499	1.848	0.248	0.386	1.499
$H_3C_3S_1R_3$	12.64	18.96	34.76	1.167	1.687	2.052	0.270	0.416	1.687
$H_3C_3S_2R_1$	11.92	17.88	32.78	1.084	1.554	1.900	0.251	0.398	1.554
$H_3C_3S_2R_2$	12.16	18.24	33.44	1.129	1.626	1.994	0.267	0.404	1.626
$H_3C_3S_2R_3$	12.53	18.79	34.54	1.183	1.713	2.080	0.275	0.413	1.713
$H_3C_4S_1R_1$	11.90	17.34	30.46	1.049	1.459	1.831	0.247	0.392	1.459
$H_3C_4S_1R_2$	11.88	17.14	30.42	1.022	1.415	1.777	0.237	0.408	1.415
$H_3C_4S_1R_3$	11.88	17.32	30.56	1.096	1.534	2.904	0.256	0.395	1.534
$H_3C_4S_2R_1$	11.83	17.25	30.29	1.044	1.450	1.820	0.245	0.391	1.450
$H_3C_4S_2R_2$	12.30	17.94	31.56	1.049	1.458	1.839	0.247	0.402	1.458
$H_3C_4S_2R_3$	11.56	16.84	29.54	1.104	1.547	2.914	0.259	0.384	1.547
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.015**	**NS**	**NS**

4.4.14 Leaf nitrate reductase activity (NRA)

The values for NRA decreased as the growth progressed and did not give any response to the treatment (Table 26). However, exogenously added hormones, twice (R_3), with the nutrient solution, enhanced the activity significantly, as compared with single applications (R_1 or R_2). Various factors, tested, interacted non-significantly.

4.4.15 Nitrate content in the shoot

The nitrate content was significantly increased by the treatment (Table 26) but decreased with the age of the plant. The maximum values were recorded with IAA (H_2) which were comparable with those of H_1 and H_3 at 25 DAS, but excelled at the later stages of growth (35 and 45 DAS). The two higher concentrations (C_3 and C_4) were at par with each other. Hormonal application twice (R_3) was far superior than single applications (R_1 or R_2). Soaking hours were non-significant. Considering the interaction effects, only the two and three factor interactions were significant. The best combinations are H_2C_4, C_3R_3 and $H_2C_4S_1$.

4.4.16 Protein content in the shoot

The plants exhibited significant response to the treatment, where GA_3 (H_1) proved most effective, at all the stages of growth (Table 27). The per cent level decreased with plant age. However, an increase in the level of the hormones significantly increased protein content, at 35 and 45 DAS and C_3 (10^{-7}M) proved best. Application of the hormones twice (R_3) proved far superior, at 25 and 35 DAS but was comparable with single applications (R_1 or R_2), at 45 DAS. Regarding interaction effect, only two factors of the

Table 26. The leaf number, level of nitrate reductase (NRA; m moles $g^{-1}h^{-1}fw$) of the leaves and nitrate ($\mu g \times 10^{-3} g^{-1}$) in the shoot of the plants, received water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M of GA_3 (H_1), IAA (H_2) or IBA (H_3) through seeds for 12 (S_1) or 18 (S_2) hours and with nutrient solution on 7th (R_1) or 14th (R_2) or both 7th and 14th (R_3) days, after the emergence of the seedlings. The sampling was done at 25, 35 and 45 days after sowing.

Treatments	Leaf number			NRA			Nitrate		
	DAYS AFTER SOWING								
	25	35	45	25	35	45	25	35	45
H_1	4.21	6.07	7.14	0.730	0.706	0.616	163	150	135
H_2	4.34	6.21	7.27	0.805	0.781	0.748	164	154	142
H_3	4.16	6.01	7.08	0.708	0.678	0.600	161	149	133
CD at 5%	**0.08**	**0.10**	**0.11**	**NS**	**NS**	**NS**	**3**	**2**	**2**
C_1	3.89	5.73	6.81	0.659	0.612	0.587	152	140	125
C_2	4.22	6.08	7.15	0.722	0.689	0.638	160	151	136
C_3	4.38	6.26	7.32	0.789	0.775	0.681	167	156	140
C_4	4.45	6.23	7.39	0.780	0.761	0.673	166	158	145
CD at 5%	**0.11**	**0.13**	**0.14**	**NS**	**NS**	**NS**	**4**	**3**	**3**
S_1	4.22	6.08	7.15	0.746	0.719	0.656	163	151	138
S_2	4.25	6.11	7.18	0.750	0.725	0.654	164	155	135
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
R_1	4.20	6.06	7.13	0.739	0.710	0.652	163	150	134
R_2	4.21	6.07	7.14	0.734	0.705	0.644	165	148	137
R_3	4.30	6.17	7.24	0.769	0.749	0.699	166	153	142
CD at 5%	**0.08**	**0.10**	**0.11**	**0.011**	**0.012**	**0.010**	**3**	**2**	**2**
H_1C_1	3.88	5.72	6.80	0.651	0.603	0.573	152	140	127
H_1C_2	4.18	6.04	7.11	0.658	0.603	0.694	162	147	139
H_1C_3	4.38	6.26	7.32	0.769	0.759	0.624	169	154	141
H_1C_4	4.29	6.17	7.33	0.767	0.754	0.625	164	155	139
H_2C_1	3.88	5.72	6.80	0.668	0.622	0.596	152	138	129
H_2C_2	4.41	6.29	7.35	0.782	0.753	0.730	170	159	140
H_2C_3	4.46	6.34	7.40	0.863	0.851	0.807	172	156	143
H_2C_4	4.51	6.40	7.55	0.806	0.850	0.819	172	165	147
H_3C_1	3.91	5.75	6.83	0.658	0.609	0.592	153	139	130
H_3C_2	4.06	5.91	6.98	0.690	0.657	0.582	158	148	130
H_3C_3	4.30	6.17	7.23	0.735	0.714	0.610	166	151	141
H_3C_4	4.26	6.13	7.29	0.760	0.680	0.577	163	157	138
CD at 5%	**0.15**	**0.18**	**0.20**	**NS**	**NS**	**NS**	**5**	**5**	**4**
H_1S_1	4.18	6.04	7.11	0.731	0.705	0.624	162	151	133
H_1S_2	4.24	6.11	7.17	0730	0.707	0.609	164	149	139
H_2S_1	4.35	6.23	7.29	0.802	0.778	0.746	168	157	138
H_2S_2	4.32	6.20	7.26	0.807	0.784	0.750	167	152	141
H_3S_1	4.13	5.98	7.06	0.704	0.673	0.597	160	150	132

H_3S_2	4.18	6.04	7.11	0.712	0.682	0.604	162	148	137
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
H_1R_1	4.18	6.04	7.11	0.722	0.693	0.620	162	151	133
H_1R_2	4.19	6.05	7.12	0.714	0.686	0.604	162	148	138
H_1R_3	4.27	6.14	7.20	0.755	0.740	0.605	165	154	136
H_2R_1	4.30	6.17	7.24	0.796	0.770	0.741	166	151	141
H_2R_2	4.31	6.18	7.24	0.788	0.761	0.730	166	155	137
H_2R_3	4.41	6.28	7.34	0.831	0.813	0.771	170	155	144
H_3R_1	4.11	5.96	7.03	0.700	0.668	0.594	159	149	131
H_3R_2	4.13	5.98	7.05	0.701	0.669	0.597	160	146	136
H_3R_3	4.23	6.10	7.17	0.722	0.696	0.609	164	153	135
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
C_1S_1	3.89	5.72	6.81	0.659	0.611	0.586	152	138	129
C_1S_2	3.90	5.74	6.82	0.659	0.612	0.587	152	143	125
C_2S_1	4.20	6.06	7.13	0.719	0.683	0.647	163	148	138
C_2S_2	4.23	6.10	7.17	0.725	0.695	0.630	164	153	135
C_3S_1	4.35	6.22	7.29	0.786	0.771	0.677	168	153	142
C_3S_2	4.41	6.29	7.35	0.793	0.779	0.684	170	159	141
C_4S_1	4.35	6.23	7.39	0.679	0.760	0.673	166	156	145
C_4S_2	4.35	6.23	7.39	0.681	0.763	0.674	166	160	141
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
C_1R_1	3.89	5.72	6.80	0.658	0.609	0.587	152	138	129
C_1R_2	3.91	5.75	6.83	0.663	0.616	0.590	153	143	126
C_1R_3	3.88	5.71	6.80	0.658	0.610	0.584	152	138	129
C_2R_1	4.18	6.04	7.11	0.713	0.675	0.642	162	152	133
C_2R_2	4.29	6.15	7.22	0.706	0.671	0.616	166	151	136
C_2R_3	4.18	6.04	7.11	0.748	0.721	0.656	162	151	137
C_3R_1	4.32	6.19	7.26	0.776	0.758	0.670	167	152	141
C_3R_2	4.28	6.15	7.22	0.760	0.739	0.660	166	155	136
C_3R_3	4.54	6.43	7.48	0.831	0.828	0.712	174	163	144
C_4R_1	4.39	6.27	7.33	0.811	0.800	0.708	169	154	143
C_4R_2	4.25	6.12	7.29	0.769	0.746	0.670	163	157	138
C_4R_3	4.51	6.40	7.56	0.801	0.789	0.683	172	161	150
CD at 5%	**0.17**	**0.20**	**0.21**	**NS**	**NS**	**NS**	**5**	**5**	**5**
S_1R_1	4.20	6.06	7.13	0.741	0.713	0.653	163	152	134
S_1R_2	4.18	6.04	7.11	0.728	0.697	0.640	162	147	137
S_1R_3	4.28	6.15	7.21	0.768	0.747	0.674	165	155	136
S_2R_1	4.19	6.05	7.12	0.737	0.708	0.650	162	148	138
S_2R_2	4.23	6.10	7.17	0.741	0.714	0.648	164	153	135
S_2R_3	4.33	6.20	7.26	0.770	0.752	0.663	167	152	142
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_1S_1$	3.88	5.71	6.79	0.651	0.603	0.571	151	142	125
$H_1C_1S_2$	3.89	5.73	6.81	0.652	0.604	0.574	152	138	129
$H_1C_2S_1$	4.14	6.00	7.07	0.694	0.648	0.640	161	150	132

$H_1C_2S_2$	4.23	6.09	7.16	0.695	0.667	0.566	164	149	139
$H_1C_3S_1$	4.32	6.19	7.26	0.778	0.762	0.620	167	156	137
$H_1C_3S_2$	4.45	6.33	7.39	0.768	0.757	0.629	171	156	145
$H_1C_4S_1$	4.29	6.16	7.33	0.770	0.758	0.624	164	158	139
$H_1C_4S_2$	4.30	6.18	7.34	0.773	0.749	0.625	165	154	144
$H_2C_1S_1$	3.88	5.72	6.80	0.668	0.622	0.596	152	142	125
$H_2C_1S_2$	3.89	5.73	6.81	0.668	0.623	0.595	152	138	129
$H_2C_2S_1$	4.43	6.31	7.37	0.779	0 751	0.723	171	159	141
$H_2C_2S_2$	4.38	6.26	7.32	0.784	0.755	0.736	169	154	143
$H_2C_3S_1$	4.47	6.36	7.42	0.860	0.846	0.807	172	161	142
$H_2C_3S_2$	4.44	6.32	7.38	0.867	0.855	0.808	171	154	145
$H_2C_4S_1$	4.53	6.42	7.57	0.862	0.844	0.819	172	165	146
$H_2C_4S_2$	4.48	6.38	7.53	0.870	0.855	0.819	171	161	149
$H_3C_1S_1$	3.90	5.74	6.82	0.659	0.609	0.591	152	143	125
$H_3C_1S_2$	3.91	5.75	6.83	0.658	0.608	0.593	153	139	130
$H_3C_2S_1$	4.02	5.87	6.94	0.685	0.651	0.577	156	146	129
$H_3C_2S_2$	4.09	5.95	7.02	0.695	0.663	0.586	159	145	135
$H_3C_3S_1$	4.25	6.12	7.18	0.727	0.704	0.604	164	154	135
$H_3C_3S_2$	4.35	6.22	7.29	0.743	0.724	0.611	168	153	142
$H_3C_4S_1$	4.24	6.11	7.28	0.705	0.677	0.575	163	156	138
$H_3C_4S_2$	4.28	6.15	7.31	0.710	0.684	0.579	164	154	143
CD at 5%	**0.25**	**0.30**	**0.32**	**NS**	**NS**	**NS**	**8**	**7**	**7**
$H_1C_1R_1$	3.89	5.73	6.81	0.650	0.601	0.575	152	142	125
$H_1C_1R_2$	3.89	5.72	6.81	0.655	0.608	0.578	152	138	129
$H_1C_1R_3$	3.87	5.71	6.79	0.649	0.602	0.566	151	142	125
$H_1C_2R_1$	4.15	6.01	7.08	0.680	0.632	0.624	161	147	137
$H_1C_2R_2$	4.23	6.09	7.16	0.669	0.633	0.554	164	153	135
$H_1C_2R_3$	4.17	6.03	7.10	0.708	0.734	0.631	162	147	137
$H_1C_3R_1$	4.35	6.22	7.29	0.757	0.745	0.616	168	157	138
$H_1C_3R_2$	4.34	6.21	7.28	0.732	0.711	0.608	168	152	142
$H_1C_3R_3$	4.46	6.35	7.40	0.817	0.823	0.648	172	160	141
$H_1C_4R_1$	4.22	6.09	7.26	0.759	0.743	0.623	162	152	141
$H_1C_4R_2$	4.20	6.07	7.23	0.760	0.742	0.635	161	155	137
$H_1C_4R_3$	4.46	6.35	7.51	0.781	0.786	0.616	170	160	148
$H_2C_1R_1$	3.87	5.71	6.79	0.665	0.617	0.595	151	142	125
$H_2C_1R_2$	3.91	5.75	6.83	0.674	0.631	0.595	153	139	130
$H_2C_1R_3$	3.87	5.71	6.79	0.666	0.681	0.597	151	142	125
$H_2C_2R_1$	4.36	6.23	7.29	0.773	0.742	0.723	168	153	141
$H_2C_2R_2$	4.49	6.38	7.44	0.749	0.711	0.703	173	161	142
$H_2C_2R_3$	4.37	6.25	7.31	0.824	0.805	0.764	169	153	143
$H_2C_3R_1$	4.41	6.29	7.35	0.851	0.836	0.795	170	159	140
$H_2C_3R_2$	4.28	6.15	7.22	0.827	0.807	0.771	166	151	140
$H_2C_3R_3$	4.68	6.58	7.63	0.912	0.909	0.855	179	167	148
$H_2C_4R_1$	4.47	6.36	7.51	0.856	0.832	0.810	170	160	148

$H_2C_4R_2$	4.45	6.34	7.49	0.860	0.842	0.817	170	163	144
$H_2C_4R_3$	4.60	6.50	7.65	0.883	0.870	0.829	175	164	152
$H_3C_1R_1$	3.89	5.73	6.81	0.658	0.609	0.591	152	142	125
$H_3C_1R_2$	3.94	5.78	6.86	0.659	0.608	0.596	154	140	131
$H_3C_1R_3$	3.89	5.72	6.81	0.658	0.610	0.599	152	142	125
$H_3C_2R_1$	4.04	5.88	6.96	0.686	0.651	0.580	157	143	133
$H_3C_2R_2$	4.13	5.99	7.06	0.699	0.668	0.592	160	150	132
$H_3C_2R_3$	4.00	5.85	6.92	0.685	0.652	0.574	156	142	132
$H_3C_3R_1$	4.20	6.06	7.13	0.719	0.694	0.598	163	152	134
$H_3C_3R_2$	4.22	6.09	7.15	0.722	0.697	0.601	163	149	139
$H_3C_3R_3$	4.48	6.36	7.42	0.765	0.751	0.632	172	161	142
$H_3C_4R_1$	4.20	6.07	7.23	0.698	0.668	0.569	161	149	141
$H_3C_4R_2$	4.11	5.97	7.14	0.685	0.653	0.559	158	152	134
$H_3C_4R_3$	4.47	6.36	7.51	0.739	0.720	0.593	170	160	148
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1S_1R_1$	4.19	6.05	7.12	0.724	0.696	0.623	162	152	134
$H_1S_1R_2$	4.17	6.03	7.10	0.712	0.683	0.606	162	147	137
$H_1S_1R_3$	4.19	6.05	7.12	0.757	0.737	0.643	162	152	134
$H_1S_2R_1$	4.17	6.03	7.10	0.719	0.689	0.616	162	147	137
$H_1S_2R_2$	4.20	6.06	7.13	0.716	0.689	0.602	163	152	134
$H_1S_2R_3$	4.35	6.22	7.29	0.754	0.742	0.607	168	153	142
$H_2S_1R_1$	4.34	6.21	7.28	0.799	0.773	0.745	168	156	138
$H_2S_1R_2$	4.30	6.17	7.23	0.780	0.751	0.724	166	151	141
$H_2S_1R_3$	4.42	6.30	7.36	0.826	0.810	0.770	170	159	140
$H_2S_2R_1$	4.26	6.13	7.20	0.794	0.768	0.737	165	150	140
$H_2S_2R_2$	4.32	6.19	7.25	0.795	0.770	0.739	167	156	137
$H_2S_2R_3$	4.39	6.27	7.33	0.833	0.816	0.773	169	154	143
$H_3S_1R_1$	4.08	5.94	7.01	0.700	0.668	0.581	159	148	131
$H_3S_1R_2$	4.07	5.92	7.00	0.691	0.657	0.590	158	144	134
$H_3S_1R_3$	4.23	6.09	7.16	0.720	0.693	0.609	164	153	135
$H_3S_2R_1$	4.13	5.99	7.06	0.700	0.668	0.597	160	146	132
$H_3S_2R_2$	4.18	6.04	7.11	0.711	0.681	0.604	162	152	137
$H_3S_2R_3$	4.24	6.10	7.17	0.724	0.698	0.610	164	149	135
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$C_1S_1R_1$	3.89	5.72	6.80	0.663	0.617	0.586	152	142	129
$C_1S_1R_2$	3.90	5.74	6.82	0.656	0.608	0.583	152	139	125
$C_1S_1R_3$	3.88	5.71	6.79	0.658	0.609	0.591	151	142	129
$C_1S_2R_1$	3.89	5.72	6.80	0.652	0.601	0.588	152	138	125
$C_1S_2R_2$	3.93	5.77	6.85	0.659	0.623	0.597	153	140	130
$C_1S_2R_3$	3.88	5.72	6.80	0.657	0.611	0.577	152	138	129
$C_2S_1R_1$	4.23	6.09	7.16	0.715	0.677	0.646	164	153	135
$C_2S_1R_1$	4.20	6.06	7.13	0.696	0.655	0.625	163	148	138
$C_2S_1R_3$	4.16	6.02	7.09	0.747	0.718	0.670	161	151	133
$C_2S_2R_1$	4.13	5.99	7.06	0.711	0.673	0.638	160	146	136

$C_2S_2R_2$	4.37	6.25	7.31	0.715	0.687	0.608	169	153	139
$C_2S_2R_3$	4.20	6.06	7.13	0.748	0.725	0.643	163	152	138
$C_3S_1R_1$	4.27	6.14	7.21	0.776	0.758	0.671	165	154	136
$C_3S_1R_2$	4.27	6.14	7.21	0.751	0.729	0.646	165	150	140
$C_3S_1R_3$	4.50	6.39	7.44	0.830	0.825	0.713	173	162	143
$C_3S_2R_1$	4.37	6.24	7.31	0.775	0.758	0.668	169	153	143
$C_3S_2R_2$	4.29	6.16	7.23	0.769	0.748	0.674	166	155	137
$C_3S_2R_3$	4.58	6.47	7.52	0.833	0.830	0.711	276	160	145
$C_4S_1R_1$	4.42	6.30	7.36	0.810	0.798	0.709	170	159	144
$C_4S_1R_2$	4.36	6.23	7.29	0.808	0.795	0.706	168	153	138
$C_4S_1R_3$	4.48	6.37	7.52	0.799	0.786	0.683	171	164	145
$C_4S_2R_1$	4.27	6.14	7.30	0.772	0.751	0.666	163	153	143
$C_4S_2R_2$	4.25	6.12	7.28	0.769	0.746	0.674	163	157	138
$C_4S_2R_3$	4.55	6.44	7.59	0.803	0.792	0.683	173	162	147
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_1S_1R_1$	3.87	5.71	6.79	0.663	0.621	0.572	151	142	129
$H_1C_1S_1R_2$	3.95	5.80	6.87	0.639	0.588	0.564	154	140	127
$H_1C_1S_1R_3$	3.81	5.64	6.72	0.649	0.599	0.579	149	140	127
$H_1C_1S_2R_1$	3.91	5.75	6.83	0.637	0.582	0.577	153	139	126
$H_1C_1S_2R_2$	3.82	5.65	6.74	0.671	0.627	0.593	150	140	127
$H_1C_1S_2R_3$	3.94	5.78	6.86	0.648	0.604	0.553	154	140	127
$H_1C_2S_1R_1$	4.22	6.09	7.16	0.685	0.637	0.636	164	153	139
$H_1C_2S_1R_2$	4.12	5.98	7.05	0.664	0.613	0.606	160	146	132
$H_1C_2S_1R_3$	4.07	5.92	7.00	0.732	0.693	0.679	158	148	134
$H_1C_2S_2R_1$	4.08	5.94	7.01	0.674	0.626	0.612	159	144	131
$H_1C_2S_2R_2$	4.33	6.20	7.27	0.674	0.653	0.502	167	156	142
$H_1C_2S_2R_3$	4.27	6.14	7.21	0.737	0.723	0.583	165	150	136
$H_1C_3S_1R_1$	4.22	6.08	7.15	0.756	0.743	0.618	163	153	138
$H_1C_3S_1R_2$	4.37	6.25	7.31	0.735	0.719	0.589	169	154	139
$H_1C_3S_1R_3$	4.38	6.25	7.32	0.819	0.825	0.652	169	158	143
$H_1C_3S_2R_1$	4.49	6.37	7.43	0.758	0.746	0.615	173	157	142
$H_1C_3S_2R_2$	4.31	6.18	7.24	0.730	0.703	0.627	166	155	141
$H_1C_3S_2R_3$	4.55	6.44	7.49	0.815	0.821	0.646	175	159	148
$H_1C_4S_1R_1$	4.33	6.21	7.37	0.753	0.734	0.625	166	159	141
$H_1C_4S_1R_2$	4.15	6.01	7.18	0.771	0.760	0.624	159	150	139
$H_1C_4S_1R_3$	4.38	6.27	7.43	0.786	0.782	0.624	168	161	142
$H_1C_4S_2R_1$	4.11	5.97	7.14	0.766	0.753	0.622	168	148	138
$H_1C_4S_2R_2$	4.15	6.12	7.29	0.749	0.723	0.646	163	157	138
$H_1C_4S_2R_3$	4.54	6.44	7.59	0.776	0.771	0.608	173	162	151
$H_2C_1S_1R_1$	3.95	5.79	6.87	0.664	0.615	0.602	154	144	127
$H_2C_1S_1R_2$	3.83	5.67	6.75	0.678	0.638	0.593	150	137	128
$H_2C_1S_1R_3$	3.86	5.70	6.78	0.662	0.613	0.595	151	141	124
$H_2C_1S_2R_1$	3.80	5.63	6.71	0.665	0.619	0.589	149	135	127
$H_2C_1S_2R_2$	3.98	5.83	6.91	0.670	0.625	0.597	155	145	128

$H_2C_1S_2R_3$	3.88	5.72	6.80	0.669	0.623	0.599	152	138	129
$H2C_2S_1R_1$	4.49	6.37	7.43	0.780	0.750	0.730	173	161	142
$H_2C_2S_1R_2$	4.40	6.28	7.34	0.734	0.695	0.685	170	154	140
$H_2C_2S_1R_3$	4.41	6.29	7.35	0.824	0.807	0.754	170	161	144
$H_2C_2S_2R_1$	4.23	6.09	7.16	0.766	0.733	0.715	164	149	135
$H_2C_2S_2R_2$	4.59	6.48	7.53	0.763	0.728	0.721	176	164	149
$H_2C_2S_2R_3$	4.33	6.21	7.27	0.824	0.803	0.773	167	152	138
$H_2C_3S_1R_1$	4.40	6.28	7.34	0.852	0.836	0.798	170	158	144
$H_2C_3S_1R_2$	4.33	6.20	7.26	0.816	0.795	0.761	167	152	138
$H_2C_3S_1R_3$	4.70	6.60	7.65	0.812	0.907	0.862	180	168	152
$H_2C_3S_2R_1$	4.43	6.31	7.37	0.858	0.835	0.793	171	155	140
$H_2C_3S_2R_2$	4.24	6.10	7.17	0.838	0.820	0.781	164	153	139
$H_2C_3S_2R_3$	4.66	6.56	7.61	0.912	0.911	0.848	179	163	147
$H_2C_4S_1R_1$	4.43	6.31	7.47	0.858	0.840	0.812	169	162	147
$H_2C_4S_1R_2$	4.53	6.42	7.57	0.851	0.828	0.817	172	162	146
$H_2C_4S_1R_3$	4.62	6.53	7.68	0.877	0.863	0.827	176	169	149
$H_2C_4S_2R_1$	4.50	6.40	7.55	0.784	0.834	0.808	172	161	149
$H_2C_4S_2R_2$	4.37	6.25	7.41	0.870	0.856	0.817	167	159	142
$H_2C_4S_2R_3$	4.58	6.48	7.63	0.887	0.876	0.832	174	163	152
$H_3C_1S_1R_1$	3.84	5.68	6.76	0.662	0.616	0.584	150	141	124
$H_3C_1S_1R_2$	3.90	5.74	6.82	0.651	0.598	0.592	152	139	130
$H_3C_1S_1R_3$	3.96	5.80	6.88	0.663	0.614	0.598	154	145	127
$H_3C_1S_2R_1$	3.95	5.79	6.87	0.654	0.601	0.597	154	140	131
$H_3C_1S_2R_2$	3.98	5.83	6.90	0.667	0.619	0.601	155	145	128
$H_3C_1S_2R_3$	3.81	5.64	6.73	0.654	0.605	0.581	149	136	127
$H_3C_2S_1R_1$	3.98	5.83	6.90	0.678	0.642	0.573	155	145	128
$H_3C_2S_1R_2$	4.07	5.93	7.00	0.690	0.657	0.584	158	144	134
$H_3C_2S_1R_3$	4.01	5.85	6.93	0.687	0.653	0.576	156	146	128
$H_3C_2S_2R_1$	4.09	5.94	7.02	0.693	0.660	0.587	159	145	135
$H_3C_2S_2R_2$	4.20	6.06	7.13	0.708	0.679	0.599	163	152	134
$H_3C_2S_2R_3$	3.99	5.84	6.92	0.684	0.650	0.573	156	142	128
$H_3C_3S_1R_1$	4.21	6.07	7.14	0.720	0.695	0.599	163	152	138
$H_3C_3S_1R_2$	4.11	5.97	7.04	0.703	0.674	0.588	160	145	132
$H_3C_3S_1R_3$	4.43	6.31	7.37	0.758	0.743	0.626	171	159	145
$H_3C_3S_2R_1$	4.19	6.05	7.12	0.717	0.692	0.597	162	148	134
$H_3C_3S_2R_2$	4.33	6.20	7.27	0.740	0.721	0.614	167	156	142
$H_3C_3S_2R_3$	4.52	6.41	7.47	0.771	0.760	0.637	174	158	43
$H_3C_4S_1R_1$	4.20	6.07	7.24	0.699	0.670	0.570	161	155	141
$H_3C_4S_1R_2$	4.09	5.95	7.12	0.682	0.648	0.557	157	148	134
$H_3C_4S_1R_3$	4.42	6.31	7.47	0.733	0.712	0.597	169	162	147
$H_3C_4S_2R_1$	4.19	6.06	7.22	0.697	0.667	0.569	161	151	137
$H_3C_4S_2R_2$	4.12	5.99	7.16	0.689	0.658	0.560	159	153	139
$H_3C_4S_2R_3$	4.51	6.41	7.56	0.746	0.728	0.608	172	161	147
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

treatment interacted significantly. The best combinations are H_1C_3 and C_3R_3.

4.4.17 Soluble carbohydrate content in the shoot

The parameter was significantly improved by the treatment and its level increased with age (Table 27). A maximum increase in the level of carbohydrate was enhanced by IAA (H_2) but was closely followed by GA_3 (H_1). Soluble carbohydrate increased with an increase in the hormones level upto 10^{-7}M (C_3) and did not change further with 10^{-5}M (C_4). Application of hormones twice (R_3) was far superior to their single applications (R_1or R_2), at all the stages of growth. The interaction effect was largely in-significant but two factor interactions H_2C_4 and C_3R_3 generated significant impact.

4.4.18 Insoluble carbohydrate content in the shoot

The treatment significantly improved the level of insoluble carbohydrate but the pattern of response was very much similar to that of soluble carbohydrate (Table 27).

4.4.19 Nitrogen, phosphorus and potassium contents in the shoot

The values for all these electrolytes increased significantly by the exogenous application of the hormones (Table 28). Like that of root, the per cent level decreased, as the age progressed. GA_3 (H_1) was most prominent in its effect by increasing the content of these nutrients to a significantly highest level, at almost all the stages of growth. An increase in their level was noted upto 10^{-7}M (C_3) of the hormones after which (i.e., C_4) no further increase was observed. The two soaking durations remained ineffective. The nutrient content gave significant response to the repeated application (R_3) only, at the later stage of growth than single applications (R_1 or R_2).

Table 27. The per cent protein and soluble and insoluble carbohydrates in the shoot of the plants, received water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M of GA_3 (H_1), IAA (H_2) or IBA (H_3) through seeds for 12 (S_1) or 18 (S_2) hours and with nutrient solution on 7th (R_1) or 14th (R_2) or both 7th and 14th (R_3) days, after the emergence of the seedlings. The sampling was done at 25, 35 and 45 days after sowing.

Treatments	Protein			Sol. carbohydrate			Insol. carbohydrate		
	DAYS AFTER SOWING								
	25	35	45	25	35	45	25	35	45
H_1	20.67	19.27	15.96	4.64	5.98	6.40	41.42	37.78	40.81
H_2	19.96	18.68	15.43	4.93	5.92	6.55	40.03	38.65	43.62
H_3	19.71	18.46	15.24	4.44	5.43	5.77	39.43	39.10	36.70
CD at 5%	**0.30**	**0.32**	**0.392**	**0.06**	**0.06**	**0.12**	**0.70**	**0.73**	**0.92**
C_1	18.22	17.20	14.11	3.78	4.76	5.20	35.10	34.26	32.57
C_2	20.03	18.73	15.47	4.60	5.65	6.10	39.30	38.10	38.66
C_3	20.21	19.48	16.14	5.02	6.20	6.66	42.34	40.15	43.90
C_4	20.30	18.81	15.43	4.97	6.12	6.69	42.43	39.53	43.38
CD at 5%	**0.34**	**0.37**	**0.45**	**0.07**	**0.07**	**0.14**	**0.81**	**0.84**	**0.83**
S_1	20.03	18.74	15.48	4.65	5.76	6.22	40.39	38.48	40.21
S_2	20.20	18.81	15.60	4.69	5.80	6.26	40.20	38.54	40.55
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
R_1	19.89	18.61	15.37	4.62	5.73	6.2	40.15	38.26	39.84
R_2	19.97	18.68	15.43	4.59	5.68	6.12	39.59	38.26	39.43
R_3	20.40	19.12	15.82	4.80	5.94	6.4	41.15	39.02	41.86
CD at 5%	**0.30**	**0.32**	**0.39**	**0.06**	**0.06**	**0.12**	**0.70**	**NS**	**0.72**
H_1C_1	18.17	17.16	14.07	3.80	4.77	5.24	35.10	34.32	32.60
H_1C_2	21.10	19.65	16.29	4.53	5.84	6.41	40.43	37.98	41.73
H_1C_3	21.29	19.80	16.42	4.96	6.46	7.09	43.85	40.30	48.48
H_1C_4	21.11	19.50	16.04	4.97	6.47	6.97	44.32	40.01	49.68
H_2C_1	18.17	17.12	14.07	3.81	4.76	5.24	35.28	34.19	32.47
H_2C_2	19.82	18.56	15.32	4.80	5.78	6.41	39.10	37.23	39.16
H_2C_3	20.92	19.49	16.15	5.37	6.37	7.09	41.89	39.21	44.46
H_2C_4	19.94	18.51	15.16	5.43	6.37	7.15	41.84	38.51	44.17
H_3C_1	18.31	17.28	14.18	3.74	4.74	5.17	34.93	34.27	32.64
H_3C_2	19.16	18.00	14.82	4.47	5.32	5.63	38.39	39.09	35.11
H_3C_3	20.53	19.16	15.85	4.74	5.76	6.03	41.27	40.96	38.76
H_3C_4	19.85	18.43	15.09	4.51	5.52	5.94	41.15	40.08	39.29
CD at 5%	**0.60**	**0.64**	**0.78**	**0.12**	**0.12**	**0.25**	**NS**	**NS**	**NS**
H_1S_1	20.58	19.35	16.03	4.64	5.97	6.52	41.51	38.61	43.41
H_1S_2	19.55	19.20	15.89	4.65	6.00	6.58	41.33	38.69	43.84
H_2S_1	20.14	18.53	15.29	4.91	5.91	6.37	40.07	37.75	40.64
H_2S_2	20.76	18.83	15.56	4.94	5.93	6.42	39.98	37.75	41.02
H_3S_1	19.87	18.33	15.11	4.41	5.41	5.77	39.58	39.08	36.60

H_3S_2	19.80	18.60	15.36	4.47	5.46	5.77	39.28	39.12	36.80
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
H_1R_2	20.51	19.14	15.84	4.56	5.85	6.40	40.58	38.35	42.28
H_1R_3	21.04	19.59	16.24	4.75	6.17	6.74	42.45	39.68	45.58
H_2R_1	19.78	18.52	15.29	4.87	5.88	6.35	39.88	37.50	40.20
H_2R_2	19.84	18.57	15.33	4.80	5.80	6.26	39.37	37.48	39.67
H_2R_3	20.27	18.94	15.66	5.11	6.09	6.58	40.83	38.37	42.57
H_3R_1	19.44	18.23	15.03	4.39	5.38	5.73	39.32	39.35	36.32
H_3R_2	19.55	18.33	15.11	4.41	5.39	5.71	38.82	38.94	36.34
H_3R_3	20.15	18.84	15.57	4.53	5.54	5.87	40.16	39.00	37.44
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
C_1S_1	18.19	17.17	14.08	3.78	4.76	5.29	34.89	34.35	32.58
C_1S_2	18.25	17.22	14.13	3.78	4.76	5.21	35.32	34.17	32.56
C_2S_1	19.92	18.64	15.39	4.56	5.61	6.08	40.23	37.94	38.41
C_2S_2	20.14	18.83	15.56	4.65	5.69	6.11	38.37	38.25	38.92
C_3S_1	20.73	19.33	16.01	5.01	6.18	6.62	42.05	40.12	43.65
C_3S_2	21.09	19.63	16.28	5.04	6.21	6.70	42.62	40.19	44.15
C_4S_1	20.29	18.80	15.43	4.96	6.11	6.67	42.38	39.50	43.19
C_4S_2	20.31	18.82	15.44	4.98	6.13	6.71	42.49	39.57	43.58
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**1.14**	**NS**	**NS**
C_1R_1	18.18	17.16	14.08	3.77	4.75	5.20	34.90	34.05	32.51
C_1R_2	18.34	17.30	14.20	3.80	4.77	5.22	35.03	34.43	32.70
C_1R_3	18.14	17.13	14.05	3.78	4.75	5.19	35.38	34.30	32.50
C_2R_1	19.84	18.57	15.33	4.57	5.59	6.09	39.68	37.97	38.00
C_2R_2	20.47	19.11	15.81	4.52	5.50	5.85	37.46	37.43	36.94
C_2R_3	19.78	18.52	15.28	4.73	5.84	6.35	40.77	38.38	41.05
C_3R_1	20.58	19.20	15.89	4.94	6.11	6.59	41.75	39.74	42.99
C_3R_2	20.35	19.01	15.72	4.84	5.98	6.44	41.18	39.24	41.96
C_3R_3	21.81	20.24	16.82	5.28	6.51	6.97	44.08	41.49	46.75
C_4R_1	19.96	18.52	15.18	4.91	6.06	6.61	42.25	39.26	42.87
C_4R_2	19.71	18.31	14.99	4.90	6.07	6.68	42.70	39.93	43.12
C_4R_3	21.23	19.60	16.14	5.10	5.24	6.77	42.36	39.41	44.16
CD at 5%	**0.06**	**0.64**	**0.78**	**0.12**	**0.12**	**0.24**	**1.40**	**NS**	**NS**
S_1R_1	19.93	18.65	15.40	4.63	5.74	6.21	40.30	38.21	39.91
S_1R_2	19.83	18.55	15.31	4.54	5.62	6.05	39.43	38.19	38.94
S_1R_3	20.36	19.01	15.72	4.79	5.93	6.39	41.44	38.93	41.78
S_2R_1	19.85	18.58	15.34	4.61	5.71	6.18	40.00	38.20	39.77
S_2R_2	20.12	18.81	15.54	4.64	5.74	6.19	39.75	38.32	39.92
S_2R_3	20.62	19.24	15.92	4.80	5.94	6.40	40.85	39.11	41.95
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

$H_1C_1S_1$	18.15	17.14	14.06	3.80	4.77	5.24	34.92	34.47	32.68
$H_1C_1S_2$	18.19	17.18	14.09	3.80	4.76	5.24	35.29	34.16	32.53
$H_1C_2S_1$	21.26	19.78	16.40	4.50	5.79	6.36	41.24	37.66	40.98
$H_1C_2S_2$	20.95	19.51	16.17	4.57	5.89	6.46	39.62	38.29	42.48
$H_1C_3S_1$	21.39	19.89	16.50	5.00	6.46	7.05	43.59	40.24	48.23
$H_1C_3S_2$	21.18	19.71	16.34	4.93	6.46	7.13	44.10	40.36	48.72
$H_1C_4S_1$	21.23	19.60	16.14	4.96	6.47	7.13	44.31	40.05	48.75
$H_1C_4S_2$	20.98	19.39	15.95	4.99	6.47	7.18	44.33	39.96	48.61
$H_2C_1S_1$	18.13	17.12	14.14	3.82	4.77	5.20	35.09	34.26	32.46
$H_2C_1S_2$	18.21	17.19	14.10	3.81	4.76	5.20	35.47	34.12	32.48
$H_2C_2S_1$	19.56	18.33	15.12	4.75	5.73	6.21	39.89	37.07	39.07
$H_2C_2S_2$	20.09	18.78	15.52	4.85	5.83	6.29	38.31	37.38	39.24
$H_2C_3S_1$	20.57	19.19	15.89	5.34	6.38	6.83	41.57	39.32	44.31
$H_2C_3S_2$	21.28	19.79	16.42	5.40	6.36	6.90	42.20	39.09	44.61
$H_2C_4S_1$	19.90	18.47	15.13	5.43	6.37	6.94	41.73	38.34	43.60
$H_2C_4S_2$	19.99	18.55	15.20	5.42	6.38	7.00	41.95	38.68	44.75
$H_3C_1S_1$	18.28	17.25	14.15	3.73	4.73	5.16	34.66	34.31	32.60
$H_3C_1S_2$	18.35	17.31	14.21	3.74	4.75	5.18	35.19	34.22	32.67
$H_3C_2S_1$	18.94	17.81	14.55	4.43	5.30	5.69	39 58	39.09	35.18
$H_3C_2S_2$	19.38	18.18	14.99	4.52	5.34	5.58	37.20	39.09	35.04
$H_3C_3S_1$	20.24	18.91	15.63	4.69	5.70	5.99	40.99	40.30	38.42
$H_3C_3S_2$	20.81	19.40	16.07	4.80	5.82	6.08	41.56	40.96	39.11
$H_3C_4S_1$	19.74	18.34	15.10	4.49	5.50	5.93	41.11	40.01	37.21
$H_3C_4S_2$	19.96	18.32	15.17	4.53	5.54	5.95	41.18	40.98	37.37
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_1R_1$	18.08	17.08	14.01	3.77	4.76	5.27	35.05	33.90	32.79
$H_1C_1R_2$	18.33	17.29	14.19	3.84	4.76	5.19	34.85	34.28	32.21
$H_1C_1R_3$	18.11	17.10	14.02	3.78	4.77	5.26	35.42	34.77	32.81
$H_1C_2R_1$	20.80	19.39	16.06	4.50	5.78	6.38	40.77	37.40	40.92
$H_1C_2R_2$	21.65	20.11	16.70	4.35	5.62	6.10	38.39	37.23	39.95
$H_1C_2R_3$	20.86	19.44	16.10	4.75	6.11	6.75	42.12	39.30	44.92
$H_1C_3R_1$	21.04	19.59	16.24	4.99	6.36	6.99	43.06	39.08	47.13
$H_1C_3R_2$	20.29	18.95	15.67	4.81	6.17	6.82	42.40	39.32	45.83
$H_1C_3R_3$	22.53	20.86	17.36	5.10	6.84	7.46	46.08	42.51	52.47
$H_1C_4R_1$	20.87	19.30	15.86	4.92	6.40	7.08	44.09	39.30	48.17
$H_1C_4R_2$	20.78	19.22	15.79	4.93	6.45	7.19	44.69	40.59	48.73
$H_1C_4R_3$	21.67	19.92	16.47	5.07	6.56	7.20	44.19	40.14	49.13
$H_2C_1R_1$	18.21	17.19	14.10	3.83	4.75	5.18	35.04	33.60	32.19
$H_2C_1R_2$	18.17	17.16	14.08	3.77	4.78	5.24	35.37	34.56	32.88
$H_2C_1R_3$	18.12	17.11	14.03	3.84	4.76	5.19	35.43	34.41	32.33
$H_2C_2R_1$	19.65	18.41	15.19	4.74	5.73	6.26	39.40	37.01	38.49
$H_2C_2R_2$	20.12	18.81	15.54	4.63	5.57	5.95	37.40	36.57	37.11

$H_2C_2R_3$	19.70	18.45	15.22	5.03	6.05	6.53	40.49	38.10	41.87
$H_2C_3R_1$	20.74	19.34	16.01	5.22	6.31	6.83	41.43	39.11	43.71
$H_2C_3R_2$	20.69	19.30	15.97	5.07	6.11	6.57	40.70	38.15	42.12
$H_2C_3R_3$	21.34	19.84	16.46	5.81	6.69	7.19	43.54	40.37	47.55
$H_2C_4R_1$	19.57	18.15	14.84	5.37	6.31	6.86	41.66	38.29	43.41
$H_2C_4R_2$	19.37	18.03	14.74	5.43	6.34	6.97	42.01	38.64	43.57
$H_2C_4R_3$	20.94	19.35	15.91	5.48	6.47	7.10	41.84	38.61	45.53
$H_3C_1R_1$	18.24	17.22	14.13	3.73	4.73	5.16	34.62	34.65	32.55
$H_3C_1R_2$	18.51	17.44	14.33	3.77	4.79	5.22	34.87	34.44	33.00
$H_3C_1R_3$	18.19	17.17	14.08	3.72	4.70	5.13	35.28	33.71	32.36
$H_3C_2R_1$	19.07	17.92	14.75	4.46	5.27	5.62	38.87	39.52	34.60
$H_3C_2R_2$	19.64	18.44	15.18	4.57	5.31	5.51	36.58	38.50	34.36
$H_3C_2R_3$	18.77	17.67	14.53	4.40	5.38	5.77	39.71	39.25	36.36
$H_3C_3R_1$	19.95	18.66	15.41	4.63	5.65	5.94	40.75	41.03	38.12
$H_3C_3R_2$	20.08	18.77	15.51	4.65	5.65	5.92	40.44	40.25	37.95
$H_3C_3R_3$	21.56	20.03	16.63	4.94	5.99	6.24	42.61	41.58	40.23
$H_3C_4R_1$	19.49	18.12	14.82	4.44	5.46	5.90	41.00	40.20	37.01
$H_3C_4R_2$	18.97	17.68	14.43	4.33	5.41	5.90	41.39	41.57	37.05
$H_3C_4R_3$	21.09	19.48	16.03	4.75	5.70	6.02	41.05	39.48	37.80
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1S_1R_1$	20.67	19.25	15.96	4.64	5.96	6.54	41.44	38.12	43.13
$H_1S_1R_2$	20.46	19.10	15.80	4.51	5.79	6.31	40.40	38.33	41.85
$H_1S_1R_3$	21.15	19.55	16.32	4.76	6.16	6.71	42.70	39.37	45.25
$H_1S_2R_1$	20.23	18.90	15.62	4.60	5.89	6.47	41.05	37.71	42.87
$H_1S_2R_2$	20.56	19.18	15.88	4.60	5.91	6.48	40.76	38.38	42.71
$H_1S_2R_3$	20.94	19.50	16.16	4.74	6.18	6.77	42.20	39.99	45.92
$H_2S_1R_1$	19.81	18.55	15.31	4.90	5.91	6.37	40.04	37.58	40.25
$H_2S_1R_2$	19.76	18.01	15.27	4.75	5.74	6.19	39.18	37.54	39.13
$H_2S_1R_3$	19.79	18.51	15.29	5.09	6.09	6.55	40.99	38.13	42.45
$H_2S_2R_1$	19.75	18.49	15.26	4.83	5.84	6.34	39.73	37.43	40.15
$H_2S_2R_2$	19.92	18.64	15.39	4.86	5.86	6.32	39.56	37.42	40.21
$H_2S_2R_3$	20.76	19.35	16.02	5.14	6.10	6.61	40.66	38.61	42.69
$H_3S_1R_1$	19.29	18.11	14.92	4.36	5.36	5.73	39.42	39.24	36.34
$H_3S_1R_2$	19.23	18.05	14.87	4.34	5.31	5.66	38.70	38.71	35.83
$H_3S_1R_3$	20.14	18.82	15.56	4.52	5.56	5.91	40.63	39.29	37.63
$H_3S_2R_1$	19.58	18.35	15.14	4.41	5.39	5.73	39.21	39.46	36.30
$H_3S_2R_2$	19.87	18.60	15.36	4.47	5.46	5.77	38.95	39.17	36.85
$H_3S_2R_3$	20.17	18.85	15.58	4.53	5.53	5.82	39.69	38.72	37.24
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$C_1S_1R_1$	18.18	17.17	14.08	3.78	4.76	5.22	34.87	34.26	32.59
$C_1S_1R_2$	18.25	17.22	14.13	3.78	4.75	5.18	34.55	34.45	32.49
$C_1S_1R_3$	18.13	17.12	14.04	3.79	4.77	5.21	35.25	34.33	32.65

$C_1S_2R_1$	18.18	17.16	14.08	3.77	4.74	5.19	34.94	33.84	32.42
$C_1S_2R_2$	18.42	17.37	14.26	3.81	4.80	5.25	35.51	34.40	32.90
$C_1S_2R_3$	18.15	17.14	14.06	3.77	4.73	5.17	35.50	34.26	32.35
$C_2S_1R_1$	20.11	18.80	15.53	4.58	5.62	6.10	40.12	37.87	38.16
$C_2S_1R_2$	19.97	18.69	15.43	4.41	5.39	5.81	38.63	37.33	36.28
$C_2S_1R_3$	19.68	18.43	15.21	4.69	5.80	6.34	41.95	38.63	40.80
$C_2S_2R_1$	19.57	18.35	15.13	4.56	5.56	6.07	39.26	38.08	37.85
$C_2S_2R_2$	20.97	19.53	16.18	4.62	5.61	5.90	36.28	37.54	37.60
$C_2S_2R_3$	19.88	18.60	15.36	4.76	5.89	6.36	39.60	39.14	41.30
$C_3S_1R_1$	20.29	18.96	15.67	4.95	6.12	6.61	41.86	39.84	43.11
$C_3S_1R_2$	20.31	18.97	15.69	4.76	5.87	6.31	40.27	39.03	41.23
$C_3S_1R_3$	21.59	20.06	16.66	5.31	6.55	6.94	44.03	41.49	46.62
$C_3S_2R_1$	20.86	19.44	16.10	4.94	6.10	6.56	41.63	39.63	42.87
$C_3S_2R_2$	20.34	19.04	15.75	4.93	6.08	6.57	42.09	39.44	42.70
$C_3S_2R_3$	22.22	20.42	16.98	5.26	6.47	6.99	44.12	41.48	46.88
$C_4S_1R_1$	20.12	18.66	15.30	4.93	6.08	6.62	42.34	39.28	42.78
$C_4S_1R_2$	19.73	18.33	15.00	4.89	6.05	6.62	42.26	39.95	42.74
$C_4S_1R_3$	21.03	19.43	15.98	4.06	6.21	6.76	42.55	39.27	42.04
$C_4S_2R_1$	19.80	18.39	15.06	4.89	6.04	6.60	42.16	39.24	42.95
$C_4S_2R_2$	19.69	18.29	14.97	4.91	6.09	6.75	43.14	39.91	43.50
$C_4S_2R_3$	21.44	19.78	16.29	5.13	6.07	6.79	42.17	39.54	44.28
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_1S_1R_1$	18.52	17.45	14.34	3.75	4.81	5.33	35.22	34.29	33.43
$H_1C_1S_1R_2$	17.89	16.92	13.86	3.90	4.74	5.15	34.24	34.29	31.72
$H_1C_1S_1R_3$	18.05	17.05	13.98	3.74	4.76	5.25	35.29	34.83	32.89
$H_1C_1S_2R_1$	17.65	16.71	13.68	3.78	4.71	5.21	34.87	33.51	32.15
$H_1C_1S_2R_2$	18.76	17.66	14.52	3.79	4.78	5.23	35.45	34.26	32.71
$H_1C_1S_2R_3$	18.17	17.15	14.07	3.83	4.79	5.27	35.54	34.71	32.73
$H_1C_2S_1R_1$	21.55	20.02	16.62	4.55	5.84	6.40	41.21	37.20	40.39
$H_1C_2S_1R_2$	21.14	19.68	16.32	4.24	5.48	6.00	39.40	37.29	38.36
$H_1C_2S_1R_3$	21.09	19.63	16.27	4.71	6.03	6.67	43.10	38.49	43.80
$H_1C_2S_2R_1$	20.05	18.75	15.49	4.45	5.72	6.36	40.33	37.59	41.05
$H_1C_2S_2R_2$	22.17	20.55	17.09	4.47	5.77	6.20	37.39	37.17	40.33
$H_1C_2S_2R_3$	20.63	19.24	15.93	4.80	6.18	6.82	41.13	40.11	46.04
$H_1C_3S_1R_1$	20.96	19.52	16.18	4.97	6.38	7.03	43.26	39.54	47.43
$H_1C_3S_1R_2$	20.58	19.20	15.89	4.74	6.09	6.70	41.56	39.21	45.24
$H_1C_3S_1R_3$	22.64	20.95	17.44	5.28	6.90	7.42	45.96	41.97	52.01
$H_1C_3S_2R_1$	21.12	19.66	16.30	5.00	6.35	6.94	42.86	38.61	46.84
$H_1C_3S_2R_2$	19.99	18.70	15.45	4.87	6.25	6.94	43.24	39.42	46.41
$H_1C_3S_2R_3$	22.42	20.76	17.28	4.91	6.79	7.51	46.20	43.05	52.92
$H_1C_4S_1R_1$	20.65	19.11	15.70	4.99	6.42	7.08	44.05	39.46	47.87
$H_1C_4S_1R_2$	21.23	19.60	16.13	4.88	6.45	7.09	44.41	40.51	49.07

$H_1C_4S_1R_3$	21.81	20.09	16.57	5.01	6.53	7.20	44.46	40.18	49.28
$H_1C_4S_2R_1$	21.09	19.48	16.03	4.85	6.39	7.07	44.13	39.13	48.45
$H_1C_4S_2R_2$	20.33	18.83	15.45	4.98	6.45	7.28	44.96	40.66	48.40
$H_1C_4S_2R_3$	21.53	19.86	16.36	5.04	6.58	7.19	43.92	40.09	48.99
$H_2C_1S_1R_1$	18.09	17.09	14.01	3.91	4.78	5.19	34.94	33.54	32.07
$H_2C_1S_1R_2$	18.57	17.50	14.37	3.71	4.78	5.26	35.14	35.04	33.29
$H_2C_1S_1R_3$	17.72	16.78	13.73	3.85	4.74	5.16	35.20	34.20	32.01
$H_2C_1S_2R_1$	18.34	17.30	14.20	3.75	4.72	5.16	35.15	33.66	32.31
$H_2C_1S_2R_2$	17.78	16.82	13.78	3.83	4.77	5.23	35.60	34.08	32.47
$H_2C_1S_2R_3$	18.51	17.45	14.33	3.83	4.79	5.21	35.66	34.62	32.65
$H_2C_2S_1R_1$	20.05	18.75	15.49	4.79	5.79	6.27	39.85	36.90	38.89
$H_2C_2S_1R_2$	19.50	18.29	15.08	4.51	5.42	5.84	38.32	36.39	36.17
$H_2C_2S_1R_3$	19.11	17.96	14.78	4.95	5.98	6.50	41.48	37.92	42.15
$H_2C_2S_2R_1$	19.25	18.07	14.89	4.70	5.67	6.25	38.94	37.11	38.09
$H_2C_2S_2R_2$	20.73	19.33	16.00	4.75	5.71	6.05	36.47	36.75	38.04
$H_2C_2S_2R_3$	20.28	18.95	15.66	5.10	6.12	6.57	39.51	38.28	41.59
$H_2C_3S_1R_1$	19.94	18.66	15.41	5.25	6.32	6.85	41.47	39.45	43.69
$H_2C_3S_1R_2$	20.90	19.47	16.13	5.01	6.03	6.44	39.80	38.01	41.53
$H_2C_3S_1R_3$	20.85	19.43	16.10	5.76	6.80	7.19	43.45	40.50	47.69
$H_2C_3S_2R_1$	21.54	20.01	16.61	5.18	6.31	6.80	41.38	38.76	43.72
$H_2C_3S_2R_2$	20.48	19.12	15.82	5.14	6.19	6.69	41.60	38.28	42.71
$H_2C_3S_2R_3$	21.82	20.25	16.82	5.87	6.58	7.20	43.63	40.23	47.40
$H_2C_4S_1R_1$	20.17	18.70	15.33	5.34	6.34	6.87	41.88	38.41	43.36
$H_2C_4S_1R_2$	19.07	17.77	14.51	5.47	6.33	6.92	41.47	38.71	42.51
$H_2C_4S_1R_3$	20.45	18.94	15.55	5.49	6.93	7.05	41.83	37.90	44.93
$H_2C_4S_2R_1$	18.87	17.59	14.35	5.40	6.27	5.84	41.44	38.17	43.47
$H_2C_4S_2R_2$	19.67	18.28	14.96	5.90	6.36	7.02	42.56	38.56	46.64
$H_2C_4S_2R_3$	21.42	19.76	16.28	5.46	6.51	7.15	41.84	39.31	46.13
$H_3C_1S_1R_1$	17.94	16.96	13.90	3.67	4.68	5.13	34.15	34.95	32.28
$H_3C_1S_1R_2$	18.29	17.26	14.16	3.73	4.72	5.14	34.27	34.02	32.47
$H_3C_1S_1R_3$	18.61	17.53	14.40	3.79	4.80	5.22	35.26	33.96	33.05
$H_3C_1S_2R_1$	18.55	17.43	14.36	3.78	4.78	5.20	34.79	34.35	32.81
$H_3C_1S_2R_2$	18.73	17.63	14.50	3.81	4.85	5.29	35.48	34.86	33.83
$H_3C_1S_2R_3$	17.76	16.81	13.76	3.65	4.61	5.04	35.30	33.45	31.67
$H_3C_2S_1R_1$	18.72	17.62	14.49	4.39	5.24	5.64	39.29	39.50	34.79
$H_3C_2S_1R_2$	19.28	18.09	14.91	4.50	5.27	5.58	38.18	38.30	34.31
$H_3C_2S_1R_3$	18.83	17.72	14.57	4.41	5.39	5.85	41.26	39.49	36.44
$H_3C_2S_2R_1$	19.42	18.21	15.01	4.52	5.29	5.60	38.44	39.53	34.41
$H_3C_2S_2R_2$	20.01	18.72	15.46	4.64	5.35	5.45	34.98	38.70	34.41
$H_3C_2S_2R_3$	18.72	17.62	14.49	4.39	5.36	5.68	38.17	39.03	36.28
$H_3C_3S_1R_1$	19.98	18.69	15.44	4.64	5.66	5.95	40.83	40.53	38.20
$H_3C_3S_1R_2$	19.45	18.25	15.04	4.53	5.50	5.78	39.44	39.87	36.92

$H_3C_3S_1R_3$	21.29	19.80	16.42	4.89	5.96	6.23	42.67	42.00	40.45
$H_3C_3S_2R_1$	19.92	18.64	15.39	4.62	5.64	5.93	40.69	41.53	38.04
$H_3C_3S_2R_2$	20.77	19.30	15.98	4.78	5.80	6.06	41.43	40.63	38.97
$H_3C_3S_2R_3$	21.82	20.26	16.83	5.00	6.03	6.25	42.54	41.17	40.31
$H_3C_4S_1R_1$	19.53	18.16	19.85	4.44	5.47	5.91	41.06	39.97	37.09
$H_3C_4S_1R_2$	19.88	17.61	14.36	4.32	5.36	5.85	40.89	40.63	36.64
$H_3C_4S_1R_3$	20.82	19.25	15.83	4.70	5.67	6.03	41.35	39.73	37.89
$H_3C_4S_2R_1$	19.45	18.09	14.79	4.43	5.45	5.89	40.92	40.43	36.93
$H_3C_4S_2R_2$	19.05	17.75	14.49	4.35	5.45	5.96	41.89	40.50	37.47
$H_3C_4S_2R_3$	21.36	19.71	16.24	4.80	5.72	6.01	40.74	39.23	37.17
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Among the interaction effect, the following treatment factors interacted significantly with the nutrients largely, at 45 DAS, H_1C_3, H_1S_1, C_3R_3, C_4R_3, $H_1C_3R_3$ (for K); $H_1S_2R_2$ (for N); $H_2S_2R_3$ (for K); $C_3S_1R_3$ (for N and K) and $H_1C_3S_2R_3$ (i.e., the exogenous application of 10^{-7}M of GA through seed soaking for 18 hours and solutions 7 and 14 days after the emergence of plumule) for N, P and K.

Table 28. The per cent nitrogen, phosphorus and potassium in the shoot of the plants, received water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M of GA_3 (H_1), IAA (H_2) or IBA (H_3) through seeds for 12 (S_1) or 18 (S_2) hours and with nutrient solution on 7th (R_1) or 14th (R_2) or both 7th and 14th (R_3) days, after the emergence of the seedlings. The sampling was done at 25, 35 and 45 days, after sowing.

Treatments	Nitrogen			Phosphorus			Potassium		
	DAYS AFTER SOWING								
	25	35	45	25	35	45	25	35	45
H_1	3.46	3.24	2.70	0.375	0.330	0.286	3.04	2.97	2.71
H_2	3.35	3.14	2.62	0.365	0.322	0.294	2.95	2.86	2.62
H_3	3.31	3.11	2.59	0.361	0.319	0.283	2.92	2.83	2.59
CD at 5%	**0.08**	**0.03**	**0.03**	**0.008**	**0.009**	**0.003**	**0.09**	**0.03**	**0.02**
C_1	3.07	2.90	2.40	0.340	0.302	0.268	2.71	2.59	2.38
C_2	3.36	3.15	2.62	0.366	0.323	0.287	2.96	2.88	2.63
C_3	3.50	3.27	2.73	0.379	0.333	0.296	3.08	3.01	2.75
C_4	3.46	3.22	2.68	0.374	0.327	0.300	3.03	2.97	2.70
CD at 5%	**0.10**	**0.04**	**0.03**	**0.009**	**0.01**	**0.003**	**0.10**	**0.03**	**0.03**
S_1	3.36	3.15	2.63	0.366	0.323	0.287	2.96	2.87	2.63
S_2	3.39	3.17	2.65	0.368	0.324	0.289	2.98	2.90	2.65
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
R_1	3.34	3.13	2.61	0.364	0.321	0.285	2.94	2.85	2.61
R_2	3.35	3.14	2.62	0.365	0.322	0.286	2.95	2.86	2.62
R_3	3.43	3.21	2.68	0.373	0.328	0.292	3.02	2.95	2.69
CD at 5%	**NS**	**0.03**	**0.03**	**NS**	**NS**	**0.003**	**NS**	**0.02**	**0.03**
H_1C_1	3.06	2.90	2.40	0.340	0.301	0.267	2..70	2.58	2.38
H_1C_2	3.53	3.30	2.76	0.381	0.335	0.298	3.11	3.05	2.78
H_1C_3	3.56	3.32	2.78	0.384	0.337	0.300	3.12	3.06	2.79
H_1C_4	3.59	3.433	2.78	0.386	0.336	0.299	3.13	3.10	2.80
H_2C_1	3.06	2.90	2.40	0.340	0.301	0.267	2.70	2.58	2.37
H_2C_2	3.33	3.12	2.60	0.363	0.320	0.285	2.93	2.84	2.60
H_2C_3	3.50	3.27	2.73	0.379	0.333	0.296	3.08	3.01	2.75
H_2C_4	3.41	3.18	2.64	0.369	0.323	0.297	2.98	2.91	2.64
H_3C_1	3.08	2.92	2.42	0.342	0.303	0.269	2.72	2.60	2.40
H_3C_2	3.22	3.03	2.52	0.354	0.313	0.278	2.84	2.74	2.51
H_3C_3	3.44	3.22	2.69	0.373	0.328	0.292	3.03	2.96	2.71
H_3C_4	3.39	3.16	2.62	0.367	0.318	0.296	2.98	2.91	2.65
CD at 5%	**NS**	**0.06**	**0.04**	**NS**	**NS**	**0.005**	**NS**	**0.06**	**0.05**
H_1S_1	348.	3.25	2.71	0.376	0.331	0.295	3.05	2.99	2.72
H_1S_2	3.45	3.23	2.69	0.374	0.329	0.293	3.03	2.96	2.70
H_2S_1	3.32	3.12	2.60	0.363	0.320	0.284	2.97	2.83	2.59
H_2S_2	3.38	3.17	2.64	0.368	0.324	0.288	2.97	2.89	2.64
H_3S_1	3.28	3.09	2.57	0.359	0.317	0.282	2.89	2.80	2.57

H3S2	3.33	3.13	2.61	0.364	0.321	0.285	2.94	2.85	2.61
CD at 5%	**NS**	**0.05**	**0.03**	**NS**	**NS**	**NS**	**NS**	**0.04**	**0.03**
H_1R_1	3.43	3.21	2.68	0.372	0.327	0.291	3.01	2.94	2.68
H_1R_2	3.44	3.22	2.68	0.373	0.328	0.292	3.02	2.95	2.69
H_1R_3	3.52	3.29	2.73	0.380	0.334	0.298	3.09	3.03	2.76
H_2R_1	3.32	3.12	2.59	0.363	0.320	0.284	2.93	2.83	2.59
H_2R_2	3.33	3.12	2.60	0.363	0.320	0.285	2.93	2.84	2.60
H_2R_3	3.40	3.18	2.65	0.370	0.325	0.290	2.99	2.91	2.66
H_3R_1	3.26	3.07	2.55	0.357	0.316	0.281	2.88	2.78	2.55
H_3R_2	3.28	3.08	2.57	0.359	0.317	0.282	2.89	2.80	2.57
H_3R_3	3.38	3.17	2.64	0.368	0.324	0.288	2.98	2.90	2.65
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
C_1S_1	3.06	2.90	2.40	0.340	0.302	0.267	2.70	2.58	2.38
C_1S_2	3.07	2.91	2.41	0.341	0.302	0.268	2.71	2.59	2.39
C_2S_1	3.34	3.14	2.61	0.364	0.321	0.286	2.94	2.86	2.62
C_2S_2	3.38	3.17	2.64	0.367	0.324	0.288	2.97	2.89	2.65
C_3S_1	3.47	3.25	2.71	0.376	0.331	0.294	3.05	2.98	2.72
C_3S_2	3.53	3.30	2.75	0.381	0.335	0.298	3.10	3.04	2.77
C_4S_1	3.46	3.22	2.68	0.374	0.322	0.300	3.03	2.97	2.70
C_4S_2	3.47	3.23	2.68	0.374	0.327	0.301	3.03	2.97	2.70
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**Ns**
C_1R_1	3.06	2.90	2.40	0.340	0.301	0.267	2.70	2.58	2.38
C_1R_2	3.09	2.92	2.42	0.342	0.303	0.269	2.72	2.61	2.40
C_1R_3	3.05	2.89	2.39	0.339	0.301	0.267	2.70	2.57	2.37
C_2R_1	3.33	3.12	2.60	0.363	0.320	0.285	2.93	2.85	2.61
C_2R_2	3.43	3.21	2.68	0.372	0.328	0.291	3.02	2.95	2.70
C_2R_3	3.32	3.12	2.59	0.363	0.320	0.284	2.92	2.83	2.59
C_3R_1	3.45	3.23	2.69	0.374	0.329	0.293	3.03	2.96	2.70
C_3R_2	3.41	3.19	2.66	0.371	0.326	0.290	3.00	3.16	2.67
C_3R_3	3.65	3.39	2.84	0.391	0.343	0.306	3.20	3.16	2.87
C_4R_1	3.41	3.18	2.64	0.369	0.23	0.297	2.98	2.92	2.65
C_4R_2	3.37	3.14	2.61	0.366	0.320	0.294	2.95	2.82	2.62
C_4R_3	3.61	3.35	2.79	0.387	0.338	0.310	3.16	3.12	2.83
CD at 5%	**0.17**	**0.06**	**0.05**	**0.02**	**NS**	**0.01**	**NS**	**0.06**	**0.05**
S_1R_1	3.34	3.14	2.61	0.365	0.321	0.286	2.94	2.86	2.61
S_1R_2	3.33	3.12	2.60	0.363	0.320	0.285	2.93	2.84	2.60
S_1R_3	3.41	3.20	2.66	0.371	0.326	0.290	3.00	2.92	2.67
S_2R_1	3.33	3.13	2.60	0.364	0.321	0.285	2.93	2.85	2.60
S_2R_2	3.37	3.16	2.64	0.367	0.324	0.288	2.97	2.89	2.64
S_2R_3	3.46	3.23	2.70	0.374	0.329	0.293	3.04	2.97	2.71
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_1S_1$	3.06	2.89	2.40	0.339	0.308	0.267	2.70	2.58	2.37
$H_1C_1S_2$	3.06	2.90	2.40	0.340	0.302	0.267	2.70	2.58	2.38
$H_1C_2S_1$	3.56	2.32	2.77	0.383	0.337	0.300	3.13	3.08	2.80
$H_1C_2S_2$	3.51	2.28	2.74	0.379	0.318	0.297	3.08	3.02	2.75

$H_1C_3S_1$	3.58	3.34	2.79	0.385	0.338	0.301	3.14	3.08	2.80
$H_1C_3S_2$	3.54	3.31	2.76	0.383	0.336	0.299	3.11	3.05	2.77
$H_1C_4S_1$	3.61	3.35	2.79	0.387	0.338	0.310	3.15	3.12	2.82
$H_1C_4S_2$	3.37	3.32	2.76	0.384	0.335	0.308	3.12	3.08	2.78
$H_2C_1S_1$	3.05	2.89	2.39	0.339	0.301	0.267	2.69	2.57	2.37
$H_2C_1S_2$	3.07	2.90	2.40	0.340	0.302	0.268	2.71	2.58	2.38
$H_2C_2S_1$	3.28	3.09	2.57	0.360	0.317	0.282	2.89	2.80	2.56
$H_2C_2S_2$	3.37	3.16	2.63	0.367	0.323	0.288	2.97	2.89	2.64
$H_2C_3S_1$	3.45	3.22	2.69	0.374	0.329	0.293	3.03	2.97	2.70
$H_2C_3S_2$	3.56	3.32	2.78	0.384	0.337	0.300	3.13	3.07	2.80
$H_2C_4S_1$	3.40	3.07	2.63	0.369	0.322	0.296	2.97	2.91	2.64
$H_2C_4S_2$	3.41	3.08	2.64	0.370	0.323	0.297	2.90	2.92	2.65
$H_3C_1S_1$	3.08	2.91	2.41	0.341	0.303	0.268	2.72	2.61	2.39
$H_3C_1S_2$	3.09	2.92	2.42	0.342	0.303	0.269	2.72	2.60	2.48
$H_3C_2S_1$	3.18	3.06	2.49	0.351	0.310	0.275	2.81	2.70	2.48
$H_3C_2S_2$	3.26	3.06	2.55	0.356	0.315	0.280	2.87	2.77	2.55
$H_3C_3S_1$	3.39	3.28	2.65	0.369	0.325	0.289	2.99	2.91	2.66
$H_3C_3S_2$	3.49	3.26	2.72	0.377	0.351	0.295	3.07	3.01	2.75
$H_3C_4S_1$	3.37	3.75	2.61	0.366	0.321	0.294	2.96	2.90	2.64
$H_3C_4S_2$	3.41	3.18	2.64	0.369	0.313	0.297	2.99	2.93	2.66
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
$H_1C_1R_1$	3.05	3.88	2.39	0.339	0.300	0.266	2.69	2.56	2.36
$H_1C_1R_2$	3.09	3.92	2.42	0.342	0.303	0.269	2.72	2.60	2.40
$H_1C_1R_3$	3.05	2.89	2.39	0.339	0.301	0.266	2.69	2.57	2.37
$H_1C_2R_1$	3.48	3.26	2.72	0.377	0.331	0.295	3.07	3.00	2.74
$H_1C_2R_2$	3.62	3.37	2.82	0.388	0.341	0.304	3.19	3.14	2.86
$H_1C_2R_3$	3.49	3.26	2.73	0.378	0.332	0.296	3.06	3.00	2.73
$H_1C_3R_1$	3.52	3.29	2.75	0.381	0.334	0.298	3.09	3.02	2.75
$H_1C_3R_2$	3.40	3.19	2.66	0.370	0.325	0.290	2.98	2.90	2.65
$H_1C_3R_3$	3.76	3.49	2.93	0.402	0.351	0.314	3.29	3.26	2.96
$H_1C_4R_1$	3.56	3.30	2.75	0.383	0.334	0.307	3.10	3.06	2.77
$H_1C_4R_2$	3.54	3.29	2.71	0.381	0.322	0.306	3.09	3.04	2.75
$H_1C_4R_3$	3.69	3.41	2.85	0.384	0.343	0.315	3.21	3.19	2.88
$H_2C_1R_1$	3.07	2.90	2.40	0.340	0.302	0.268	2.71	2.59	2.38
$H_2C_1R_2$	3.06	2.90	2.40	0.340	0.301	0.267	2.70	2.58	2.38
$H_2C_1R_3$	3.05	2.89	2.39	0.339	0.301	0.267	2.69	2.57	2.37
$H_2C_2R_1$	3.30	3.10	2.58	0.361	0.318	0.283	2.91	2.82	2.58
$H_2C_2R_2$	3.37	3.16	2.64	0.367	0.324	0.288	2.97	2.89	2.65
$H_2C_2R_3$	3.31	3.11	2.58	0.362	0.319	0.284	2.91	2.82	2.58
$H_2C_3R_1$	3.47	3.25	2.71	0.376	0.331	0.295	3.05	2.99	2.72
$H_2C_3R_2$	3.47	3.24	2.71	0.375	0.330	0.294	3.05	2.98	2.72
$H_2C_3R_3$	3.57	3.33	2.78	0.385	0.337	0.301	3.13	3.08	2.80
$H_2C_4R_1$	3.34	3.12	2.58	0.363	0.318	0.292	2.92	2.85	2.59
$H_2C_4R_2$	3.32	3.10	2.57	0.362	0.316	0.291	2.90	2.82	2.57
$H_2C_4R_3$	3.57	3.31	2.76	0.383	0.334	0.307	3.11	3.07	2.78

$H_3C_1R_1$	3.07	2.91	2.41	0.341	0.302	0.268	2.71	2.59	2.39
$H_3C_1R_2$	3.11	2.94	2.44	0.344	0.305	0.271	2.75	2.63	2.42
$H_3C_1R_3$	3.06	2.90	2.40	0.340	0.302	0.267	2.70	2.58	2.38
$H_3C_2R_1$	3.20	3.02	2.51	0.352	0.312	0.276	2.83	2.72	2.50
$H_3C_2R_2$	3.30	3.10	2.58	0.360	0.318	0.282	2.91	2.82	2.58
$H_3C_2R_3$	3.16	2.98	2.47	0.349	0.308	0.274	2.79	2.68	2.46
$H_3C_3R_1$	3.35	3.14	2.62	0.365	0.322	0.286	2.95	2.87	2.62
$H_3C_3R_2$	3.37	3.16	2.63	0.367	0.323	0.287	2.97	2.89	2.64
$H_3C_3R_3$	3.61	3.36	2.81	0.387	0.340	0.303	3.17	3.13	2.85
$H_3C_4R_1$	3.33	3.11	2.58	0.362	0.318	0.292	2.93	2.85	2.60
$H_3C_4R_2$	3.25	3.04	2.52	0.355	0.312	0.286	2.85	2.77	2.53
$H_3C_4R_3$	3.59	3.33	2.78	0.384	0.336	0.308	3.15	3.11	2.82
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.09**
$H_1S_1R_1$	3.46	3.24	2.70	0.375	0.330	0.294	3.04	2.97	2.71
$H_1S_1R_2$	3.43	3.21	2.68	0.372	0.327	0.291	3.01	2.94	2.68
$H_1S_1R_3$	3.54	3.30	2.76	0.382	0.335	0.299	3.11	3.05	2.77
$H_1S_2R_1$	3.39	3.18	2.65	0.369	0.325	0.289	2.98	2.90	2.65
$H_1S_2R_2$	3.45	3.22	2.89	0.374	0.329	0.293	3.03	2.96	2.70
$H_1S_2R_3$	3.51	3.27	2.74	0.379	0.333	0.297	3.07	3.01	2.74
$H_2S_1R_1$	3.32	3.12	2.60	0.363	0.320	0.285	2.93	2.84	2.60
$H_2S_1R_2$	3.32	3.11	2.59	0.362	0.320	0.284	2.92	2.83	2.59
$H_2S_1R_3$	3.32	3.12	2.60	0.363	0.320	0.284	2.92	2.83	2.58
$H_2S_2R_1$	3.31	3.11	2.59	0.362	0.319	0.284	2.92	2.83	2.69
$H_2S_2R_2$	3.34	3.14	2.61	0.365	0.321	0.286	3.94	2.85	2.61
$H_2S_2R_3$	3.48	3.25	2.71	0.376	0.331	0.295	3.05	2.99	2.73
$H_3S_1R_1$	3.24	3.05	2.54	0.356	0.314	0.279	2.86	2.96	2.53
$H_3S_1R_2$	3.23	3.04	2.53	0.355	0.313	0.278	2.85	2.75	2.52
$H_3S_1R_3$	3.38	3.17	2.64	0.367	0.324	0.288	2.98	2.90	2.65
$H_3S_2R_1$	3.29	3.09	2.57	0.359	0.317	0.282	2.90	2.81	2.57
$H_3S_2R_2$	3.33	3.13	2.61	0.364	0.321	0.285	2.94	2.85	2.61
$H_3S_2R_3$	3.38	3.17	2.64	0.368	0.324	0.288	2.98	2.90	2.65
CD at 5%	**NS**	**NS**	**0.06**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.06**
$C_1S_1R_1$	3.06	2.90	2.40	0.340	0.301	0.267	2.70	2.58	2.38
$C_1S_1R_2$	3.07	2.91	2.41	0.341	0.302	0.268	2.71	2.59	2.39
$C_1S_1R_3$	3.05	2.89	2.39	0.339	0.301	0.267	2.69	2.57	2.37
$C_1S_2R_1$	3.06	2.90	2.40	0.340	0.301	0.267	2.70	2.58	2.38
$C_1S_2R_2$	3.10	2.93	2.43	0.343	0.304	0.267	2.74	2.62	2.41
$C_1S_2R_3$	3.06	2.89	2.40	0.339	0.301	0.270	2.70	2.57	2.37
$C_2S_1R_1$	3.37	3.16	2.63	0.367	0.323	0.288	2.97	2.89	2.65
$C_2S_1R_2$	3.35	3.14	2.62	0.365	0.322	0.286	2.95	2.87	2.63
$C_2S_1R_3$	3.30	3.10	2.58	0.361	0.319	0.283	2.90	2.81	2.57
$C_2S_2R_1$	3.29	3.09	2.57	0.360	0.317	0.282	2.89	2.80	2.57
$C_2S_2R_2$	3.51	3.28	2.74	0.379	0.333	0.297	3.09	3.03	2.77
$C_2S_2R_3$	3.33	3.13	2.61	0.364	0.321	0.285	2.93	2.85	2.60
$C_3S_1R_1$	3.40	3.19	2.66	0.370	0.326	0.290	2.99	2.91	2.66

$C_3S_1R_2$	3.41	3.19	2.66	0.370	0.326	0.290	2.99	2.92	2.66
$C_3S_1R_3$	3.61	3.36	2.82	0.388	0.340	0.303	3.17	3.12	2.84
$C_3S_2R_1$	3.49	3.26	2.73	0.378	0.332	0.296	3.07	3.00	2.74
$C_3S_2R_2$	3.42	3.20	2.67	0.371	0.327	0.291	3.00	2.93	2.67
$C_3S_2R_3$	3.68	3.42	2.67	0.394	0.345	0.308	3.23	3.19	2.90
$C_4S_1R_1$	3.43	3.20	2.66	0.372	0.325	0.299	3.01	2.95	2.68
$C_4S_1R_2$	3.37	3.15	2.61	0.366	0.321	0.295	2.95	2.88	2.62
$C_4S_1R_3$	3.58	3.32	2.77	0.384	0.335	0.308	3.13	3.09	2.80
$C_4S_2R_1$	3.38	3.16	2.62	0.367	0.321	0.295	2.96	2.89	2.63
$C_4S_2R_2$	3.37	3.14	2.60	0.366	0.320	0.294	2.94	2.87	2.61
$C_4S_2R_3$	3.65	3.38	2.82	0.390	0.345	0.312	3.19	3.16	2.81
CD at 5%	**NS**	**NS**	**0.07**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.07**
$H_1C_1S_1R_1$	3.12	2.94	2.44	0.345	0.305	0.271	2.75	2.64	2.42
$H_1C_1S_1R_2$	3.02	2.86	2.37	0.336	0.298	0.264	2.66	2.53	2.34
$H_1C_1S_1R_3$	3.04	2.88	2.38	0.338	0.300	0.266	2.68	2.56	2.36
$H_1C_1S_2R_1$	2.98	2.82	2.34	0.333	0.295	0.262	2.63	2.49	2.30
$H_1C_1S_2R_2$	3.16	2.98	2.47	0.348	0.308	0.273	2.78	2.67	2.46
$H_1C_1S_2R_3$	3.06	2.90	2.40	0.340	0.301	0.267	2.70	2.58	2.37
$H_1C_2S_1R_1$	3.60	3.36	2.81	0.387	0.340	0.303	3.17	3.13	2.85
$H_1C_2S_1R_2$	3.54	3.30	2.76	0.381	0.335	0.298	3.12	3.06	2.79
$H_1C_2S_1R_3$	3.53	3.30	2.75	0.381	0.335	0.298	3.10	3.04	2.77
$H_1C_2S_2R_1$	3.36	3.15	2.63	0.367	0.323	0.287	2.96	2.88	2.63
$H_1C_2S_2R_2$	3.70	3.44	2.88	0.396	0.347	0.309	3.26	3.23	2.93
$H_1C_2S_2R_3$	3.46	3.23	2.70	0.374	0.329	0.293	3.03	2.96	2.70
$H_1C_3S_1R_1$	3.51	3.28	2.74	0.379	0.333	0.297	3.07	3.01	2.74
$H_1C_3S_1R_2$	3.45	3.23	2.69	0.374	0.329	0.293	3.02	2.95	2.69
$H_1C_3S_1R_3$	3.78	3.51	2.94	0.403	0.352	0.315	3.31	3.28	2.97
$H_1C_3S_2R_1$	3.53	3.30	2.76	0.382	0.335	0.299	3.10	3.04	2.76
$H_1C_3S_2R_2$	3.35	3.15	2.62	0.366	0.322	0.287	2.94	2.86	2.61
$H_1C_3S_2R_3$	3.75	3.48	2.92	0.400	0.350	0.312	3.28	3.25	2.94
$H_1C_4S_1R_1$	3.62	3.27	2.72	0.379	0.331	0.304	3.07	3.02	2.74
$H_1C_4S_1R_2$	3.61	3.35	2.79	0.387	0.338	0.310	3.15	3.12	2.82
$H_1C_4S_1R_3$	3.71	3.43	2.86	0.395	0.344	0.316	3.13	3.21	2.90
$H_1C_4S_2R_1$	3.59	3.33	2.78	0.386	0.336	0.309	3.13	3.09	2.80
$H_1C_4S_2R_2$	3.47	3.13	2.68	0.375	0.327	0.301	3.03	2.97	2.69
$H_1C_4S_2R_3$	3.66	3.39	2.83	0.392	0.341	0.314	3.19	3.16	2.86
$H_2C_1S_1R_1$	3.05	2.88	2.39	0.339	0.307	0.266	2.69	2.57	2.36
$H_2C_1S_1R_2$	3.12	2.95	2.45	0.345	0.306	0.271	2.76	2.64	2.43
$H_2C_1S_1R_3$	2.99	2.85	2.34	0.333	0.296	0.262	2.64	2.51	2.31
$H_2C_1S_2R_1$	3.09	2.92	2.42	0.342	0.303	0.269	2.72	2.61	2.40
$H_2C_1S_2R_2$	3.00	2.84	2.35	0.334	0.297	0.263	2.65	2.52	2.32
$H_2C_1S_2R_3$	3.11	2.94	2.44	0.344	0.305	0.271	2.75	2.63	2.42
$H_2C_2S_1R_1$	3.36	3.15	2.63	0.367	0.323	0.287	2.96	2.88	2.64
$H_2C_2S_1R_2$	3.27	3.08	2.56	0.359	0.317	0.281	2.89	2.79	2.56
$H_2C_2S_1R_3$	3.21	3.03	2.51	0.354	0.312	0.277	2.82	2.72	2.49

$H_2C_2S_2R_1$	3.23	3.04	2.53	0.355	0.314	0.279	2.85	2.75	2.53
$H_2C_2S_2R_2$	3.47	3.25	2.71	0.376	0.331	0.294	3.06	2.99	2.73
$H_2C_2S_2R_3$	3.40	3.19	2.66	0.370	0.325	0.290	2.99	2.92	2.66
$H_2C_3S_1R_1$	3.35	3.14	2.61	0.365	0.322	0.286	2.94	2.86	2.61
$H_2C_3S_1R_2$	3.50	3.27	2.73	0.378	0.332	0.296	3.08	3.01	2.75
$H_2C_3S_1R_3$	3.49	3.26	2.73	0.378	0.332	0.296	3.06	2.99	2.73
$H_2C_3S_2R_1$	3.60	3.36	2.81	0.387	0.340	0.303	3.16	3.12	2.84
$H_2C_3S_2R_2$	3.43	3.21	2.68	0.373	0.328	0.292	3.02	2.95	2.69
$H_2C_3S_2R_3$	3.65	3.40	2.84	0.392	0.343	0.306	3.20	3.16	2.87
$H_2C_4S_1R_1$	3.44	3.21	2.66	0.373	0.326	0.299	3.01	2.96	2.68
$H_2C_4S_1R_2$	3.27	3.06	2.53	0.358	0.313	0.288	2.86	2.78	2.53
$H_2C_4S_1R_3$	3.49	3.25	2.70	0.376	0.329	0.302	3.04	2.99	2.71
$H_2C_4S_2R_1$	3.23	3.03	2.51	0.354	0.311	0.285	2.82	2.74	2.49
$H_2C_4S_2R_2$	3.36	3.14	2.60	0.365	0.320	0.294	2.94	2.87	2.60
$H_2C_4S_2R_3$	3.65	3.38	2.82	0.389	0.340	0.312	3.28	3.14	2.84
$H_3C_1S_1R_1$	3.02	2.86	2.37	0.336	0.299	0.265	2.67	2.54	2.34
$H_3C_1S_1R_2$	3.08	2.91	2.41	0.341	0.303	0.268	2.72	2.60	2.39
$H_3C_1S_1R_3$	3.12	2.96	2.45	0.346	0.301	0.272	2.76	2.65	2.44
$H_3C_1S_2R_1$	3.13	2.95	2.44	0.345	0.306	0.271	2.75	2.64	2.43
$H_3C_1S_2R_2$	3.15	2.97	2.47	0.348	0.308	0.273	2.78	2.67	2.45
$H_3C_1S_2R_3$	2.99	2.84	2.35	0.334	0.297	0.263	2.64	2.51	2.32
$H_3C_2S_1R_1$	3.15	2.97	2.47	0.347	0.308	0.273	2.78	2.67	2.45
$H_3C_2S_1R_2$	3.24	3.05	2.53	0.355	0.314	0.279	2.85	2.76	2.53
$H_3C_2S_1R_3$	3.17	2.99	2.48	0.349	0.301	0.274	2.79	2.69	2.47
$H_3C_2S_2R_1$	3.26	3.07	2.55	0.357	0.316	0.280	2.87	2.78	2.55
$H_3C_2S_2R_2$	3.36	3.15	2.62	0.365	0.322	0.286	2.96	2.88	2.63
$H_3C_2S_2R_3$	3.15	2.97	2.47	0.348	0.308	0.273	2.78	2.67	2.45
$H_3C_3S_1R_1$	3.35	3.14	2.62	0.365	0.322	0.286	2.95	2.87	2.63
$H_3C_3S_1R_2$	3.27	3.07	2.56	0.358	0.316	0.281	2.88	2.79	2.55
$H_3C_3S_1R_3$	3.56	3.32	2.78	0.383	0.337	0.300	3.14	3.08	2.81
$H_3C_3S_2R_1$	3.34	3.14	2.61	0.364	0.321	0.286	2.94	2.86	2.62
$H_3C_3S_2R_2$	3.47	3.24	2.71	0.375	0.330	0.294	3.05	2.99	2.73
$H_3C_3S_2R_3$	3.65	3.40	2.84	0.391	0.343	0.306	3.21	3.17	2.89
$H_3C_4S_1R_1$	3.34	3.12	2.59	0.363	0.318	0.292	2.93	2.86	2.60
$H_3C_4S_1R_2$	3.24	3.03	2.51	0.354	0.311	0.285	2.84	2.76	2.51
$H_3C_4S_1R_3$	3.55	3.30	2.74	0.381	0.333	0.306	3.11	3.07	2.79
$H_3C_4S_2R_1$	3.33	3.11	2.58	0.362	0.317	0.291	2.92	2.85	2.59
$H_3C_4S_2R_2$	3.36	3.05	2.53	0.357	0.313	0.287	2.86	2.78	2.54
$H_3C_4S_2R_3$	3.34	3.37	2.81	0.388	0.339	0.311	3.19	3.16	2.86
CD at 5%	**NS**	**NS**	**0.13**	**NS**	**NS**	**0.013**	**NS**	**NS**	**0.13**

Chapter 5

DISCUSSION

DISCUSSION

Even though, the genes are recognized regulators of plant growth and development, the path of development is nonetheless very much under hormonal control to produce the form that is recognized as a plant. It is either via the changes in hormone levels in response to changes in gene transcription or with the hormones themselves as regulators of gene transcription. A frequent lack of correlation between hormones concentration in the tissue and its response lead Trewavas (1981a,b, 1982, 1983) to suggest that the response is not always via the change in hormones concentration but must be attributed to changes in the sensitivity of the tissue. While our undestanding on factors influencing sensitivity or responsiveness to hormones is very elementary. Documentation of differential sensitivities, elucidation of hormone binding and understanding of the mechanism of gene expression are regularly increasing. This will help in understanding the potential mechanism for the regulation of hormone sensitivity by the tissue. Firn (1986) explained the term sensitivity as the observation that the response to a given amount of the hormone has changed. It may be due to a change in the number of receptors, a change in the affinity of the receptors or a shift in the subsequent chain of events. Hormone concentration was suggested to play a major role in hormonal regulation. He is of the view that even if sensitivity changed, there could be a response to a change in hormone concentration. Moreover, a change in the response to a given hormone may also be influenced by a shift in the level of other hormones, change in the genotype, the tissue, the age and the physiological condition of the plant.

Arteca (1997) recognized four major stages during seed germination and in the early life span of the seedlings: (a) absorption of water (b) activation or formation of enzyme system (c) metabolism of storage products, their subsequent transport and the synthesis of new material and (d) emergence of radicle and growth of the seedling. Some of these important aspects were selected for the present study, at the level of the seed and the seedling, under the impact of the auxin or gibberellin through pre-sowing seed treatment and/or their application to the roots, with the nutrient solution.

The hydrolysis of the reserves in the cotyledons/endosperm of the germinating seed basically fulfills all the early requirements of the embryo for simpler substances (Bewly and Black, 1982; Sharma and Sengupta, 1987). The level of both soluble and insoluble forms of the carbohydrates in the pea cotyledons, therefore, decreased as the germination progressed, from 6 to 18 hours (Table 3). These observations slightly deviate from those of Hayat (1996) and that may be because of the selection of late stage (i.e., 24 hours) of seed germination by him. These simpler carbohydrates, at the level of the embryo, are consumed as a source of energy or the building blocks for the synthesis of new additional material, required for cell division and its growth (Berlyn, 1972; Mayer and Poljakoff-Meyber, 1989). It may be the possible reason for the observed increase in the level of insoluble carbohydrates in the embryo (Table 4).

The protein content, in the cotyledons of the germinating seeds, also decreased (Beevers, 1968 and Table 3) because of the hydrolytic action of the proteases leading to the release of its constituents (Sathiamoorthy and Vivekanandan, 1990). These simpler substances are carried to the embryonic axes (Thambidurai and Janardanan, 1990) which is obviously a better sink (Guardia and Benelloch, 1980) because of its higher metabolic activity. It facilitated the synthesis of additional quantities of the specific proteins required for the growth of the embryo, at each subsequent stage of germination, therefore, total value of the protein increased (Table 4).

Moreover, the activity of nitrate reductase (NR) increased, both in the cotyledons and the embryonic axes, as the germination progressed and had an inverse relationship with the level of the nitrate (Tables 3 and 4). It is quite evident from the data that the cotyledons were more efficient in the process of reduction of nitrate, than the embryonic axes as the former possessed more enzyme than the later. Therefore, sufficient quantity of the reduced form of the nitrate is made available to ease the embryonic requirement. It gives an impression that the nitrate is not transported as such from the cotyledons to the embryonic axes, during the early process of germination of the seed. A similar observation has also been made by Menary and Jones (1972) and Hayat (1996). Increased activity of NR in germinating seeds of *Fagopyrum* spp. (Tahir and Farooq, 1989) and pea (Hayat, 1996) is reported earlier.

The nutrient (NPK) requirement of the growing embryo, during the initial period of germination, is met from the reserves of the cotyledons/

endosperm (Krishnamoorthy, 1993; Hopkins, 1995). Therefore, the level of all these elements increased in the embryonic axes on the expense of that of the cotyledons (Tables 3 and 4), as the germination progressed. The bathing medium did not contain any element, therefore, their decrease in the cotyledons was very significant (Table 3).

To my surprise, all these parameters, mentioned above, did not show any significant response to the exogenously supplied hormones (auxins and gibberellin), during this early period of germination (6 to 18 hours). The seeds are possibly loaded with sufficient quantity of these hormones, in the reserve form, thus need no additional quantities to boost seed vigour during this short span of germination but may be required at the later stages of growth of the embryo.

In the second phase, the seeds pre-treated with hormones were germinated in sand. The seedlings were irrigated with full nutrient solution (Tables 1 and 2). The seedlings, with intact roots, were sampled 25, 35 and 45 days, after sowing. The physio-chemical characteristics of root and shoot were assessed, separately.

The seedlings raised from the seeds treated with hormones possessed longer roots with more fresh and dry weight (Table 5). The two auxins (IAA and IBA) proved their superiority, over gibberellic acid (GA_3) in favouring root growth. It may be because of many reasons, including the direct involvement of the auxins in cell division and their elongation (Nandwal and Bharti, 1982; Haque, 1989), increased water uptake (Martin and Northcote, 1982) or the observed increase in the availability of the basic substances (Table 8). In other crops also, the root growth was favoured by the auxins (Pilet and Saugy, 1987; Mishirky *et al.*, 1990; Kalib, 1992; Rehman *et al.*, 1994). In an interesting observation, Sharma (1982), elevated the level of the hormones of the developing seeds by their application to the immature pods. These seeds, on germination, produced seedlings with higher vigour. This better performance of the root, as suggested by Sircar and Kandu (1960), is the result of the improved level of the hormone (IAA) which during the treatment is removed in sufficient quantities and fixed in the form of its conjugates which release the active form of the hormone at the later stages of growth of the seedlings. Similarly, a significant amount of GA is stored, as reversible conjugate, during seed maturation and germination, in maize (Rood *et al.*, 1983). The induced synthesis of the additional quantities of the NR (Table 6) either by the elevated level of the hormones (Roth-Bajerano and Lips, 1969; Chanda *et al.*, 1998) or its substrate (Afridi and Hewit, 1964 and Table 6) may be an additional reason to defend the observed healthy growth of the root. The effect was more prominent if the level of the hormones was increased in the soaking medium or the soaking duration in the hormones was extended to 18 hours.

The establishment of the strong root system, in the seedlings, by the hormones is naturally expected to bear luxurient shoot growth (Anderson, *et al.*, 1988a,b; Mohsen-Awalif *et al.*, 1994 and Tables 9 to 12). Plant height, leaf number, fresh and dry weight of the shoot is favoured most by GA_3 which is in agreement with the observations reported earlier, in other crops (Hore *et al.*, 1988; Mishirky *et al.*, 1990; Dhankar and Singh, 1996). Higher activity of NR, at the level of the shoot, may be because of its induced synthesis by the hormone (Ahmad, 1994; Mohsen-Awalif *et al.*, 1994; Chanda *et al.*, 1998) or the observed increase in the level of its substrate (Table 10) which is also its inducer (Afridi and Hewit, 1964).

In the third phase, the hormones, instead of being supplied to the seeds, were added to the rooting medium (sand), either once (7th or 14th day, of the emergence of the seedlings) or twice (7th and 14th day), with the nutrient solution. Root and shoot were assessed for various characteristics in the same way as in the earlier experiment.

It is quite prominent from tables 13 to 20 that, like the previous experiment, the treatment significantly enhanced the values for almost all the characteristics of the root and the shoot, including the status of the nutrients, carbohydrates and proteins which were non-significant in the earlier experiment. A possible reason for this discrepancy may be the site of application and/or the duration of the treatment with the hormones. In the seed soaking treatment the duration was time bound where a definite quantity of the hormone must have been taken up by the seed from the bathing medium and fixed (conjugate) to boost the vigour of the seed and the resulting seedling. However, in the present case, the hormones were available in the vicinity of the root which can explore them for a longer duration, that for example may be few days for GA_3, applied to the soil

(Anderson *et al.*, 1988a,b). Similarly, a positive significance of higher concentrations and longer durations of GA treatment to the roots of dwarf pea is acclaimed by Anderson *et al.* (1988a,b) where the excess quantity of GA were stored, as conjugate, for later use by the plants (O'Neil *et al.*, 1986). Moreover, the glucosides and glucosyl esters of the hormones are readily transported within the plants (Garcia-Martinez *et al.*, 1981) and hydrolized back to the active form by enzymic or chemical hydrolysis (Schneider, 1983). The involvement of GA_3 in photosynthesis (Arteca and Dong, 1981) and influencing partioning of the biomass and shoot/root ratio (Beck, 1996; Munns and Cramer, 1996) made it the most effective treatment for shoot growth, in my study.

Lastly, the pre-sowing seed treatment with the hormones (Experiment 2) was associated with the supply of additional quantities of the hormones once (7th or 14th day) or twice (7th and 14th day) to the seedlings raised in sand culture (Experiment 3). It is evident from tables 21 to 28 that the significance of the treatment on various parameters is very much prominent, as compared with that of the 3rd Experiment (page 47 to 52), where all the characteristics were favourably affected. The roots exhibited greater response to IAA and the shoot to GA_3. As these seedlings have received hormones from two different sources (seeds and roots), at different intervals, therefore, are expected to possess larger quantities of the hormones, at any stage of growth, in comparison with any other experiment, where the supply was restricted through either of these sources only. This could have resulted in the prominent response by the seedlings which is also supported by Anderson *et al.* (1988a,b) who could generate prolonged effect in the seedlings by making gibberellic acid available for a longer duration, at higher concentrations.

The suitability of the treatment is further reflected in the regression lines of the data. A range (10^{-8} to 10^{-6} M), of the hormones concentration, generated best results with regard to the growth of the root (Fig. 1) and shoot (Fig. 2) and the level of various other parameters studied (Figs. 3 to 6).

As the plant response to the hormones is tissue, stage and species based (Firn, 1986; Sood *et al.*, 1996), therefore, the interaction effect, between various parameters, has been varying to different degrees (Experiments 2, 3 and 4) or has been totally non-significant (Experiment 1). The treatment of the seed with $H_1C_4S_2$ (i.e., pre-treatment of the seeds with 10^{-5} M of GA_3 for 12 hours), $H_1C_3R_3$ (i.e., repeated application of GA_3 at 10^{-7} M) or $H_2C_4S_1$ (i.e., pre-treatment of the seeds with 10^{-5} M of IBA for 6 hours) proved to be the best possible combinations for inducing maximum growth response in the seedlings.

It may be emphasized here that even though the seeds *per se* are loaded with sufficient quantities of the hormones and the resulting seedlings, after a definite interval, become autotrophs but still there is a clear chance to improve their potentiality by increasing their hormonal level, to a optimal concentration, at either of these two stages. Moreover, the selection of the proper hormones, or a combination of hormones and the stage of application are of prime importance.

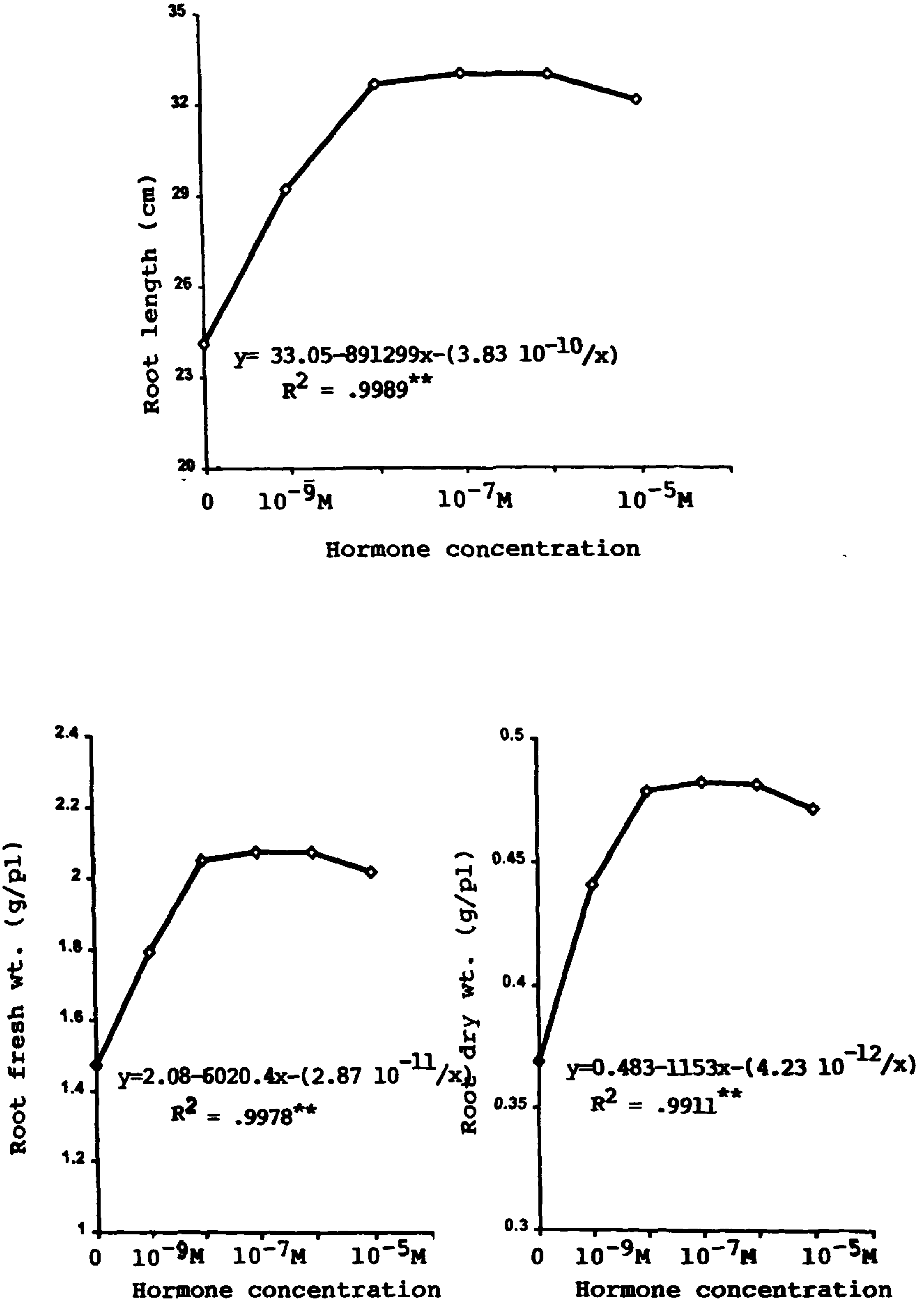

Fig. 1. Regression results showing the relation between the concentration of the hormone and the root length, fresh and dry weight in pea.

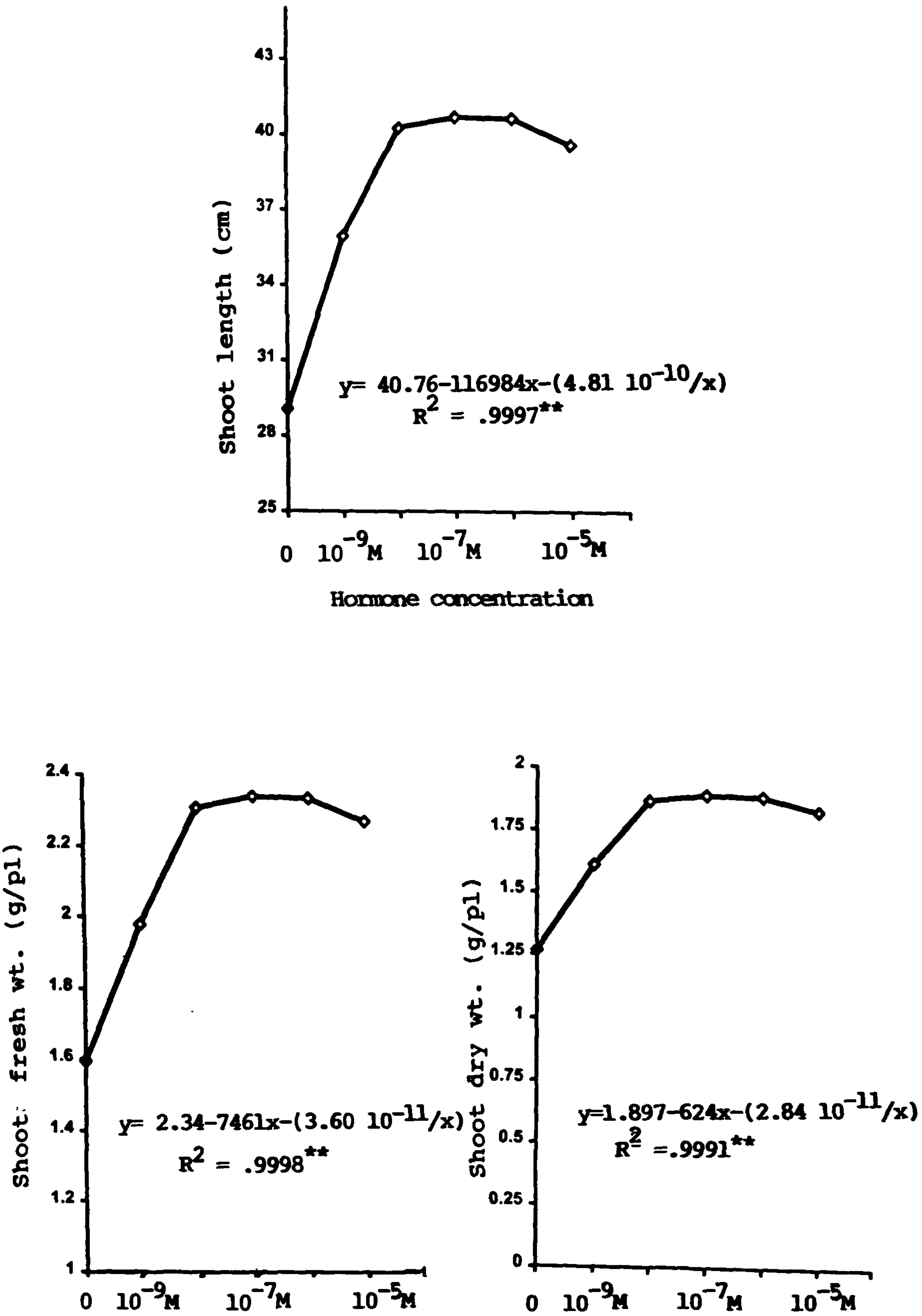

Fig. 2. Regression results showing the relation between the concentration of the hormone and the shoot length, fresh and dry weight in pea.

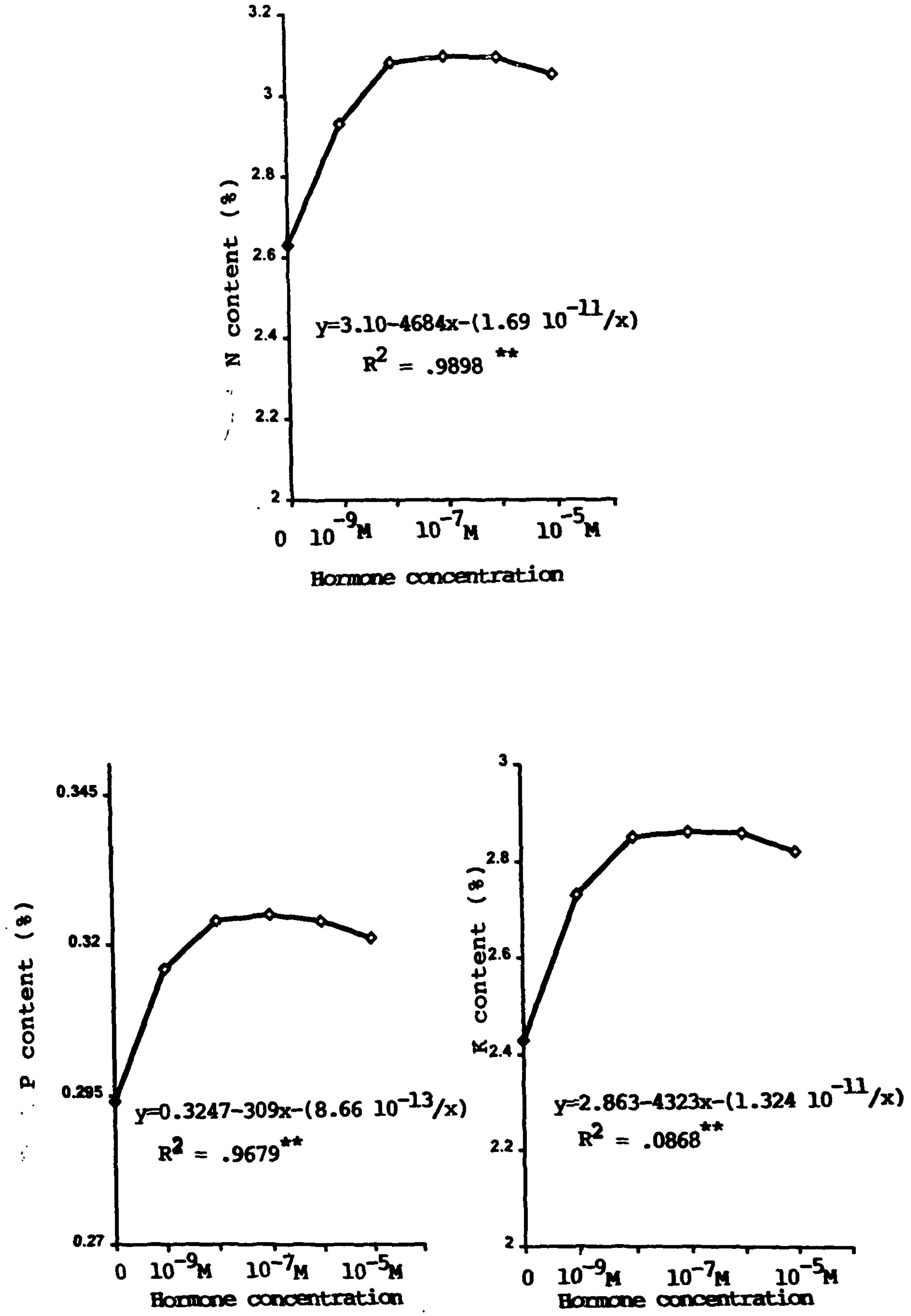

Fig. 3. Regression results showing the relation between the concentration of the hormone and the contents of nitrogen, phosphorus and potassium in root of pea.

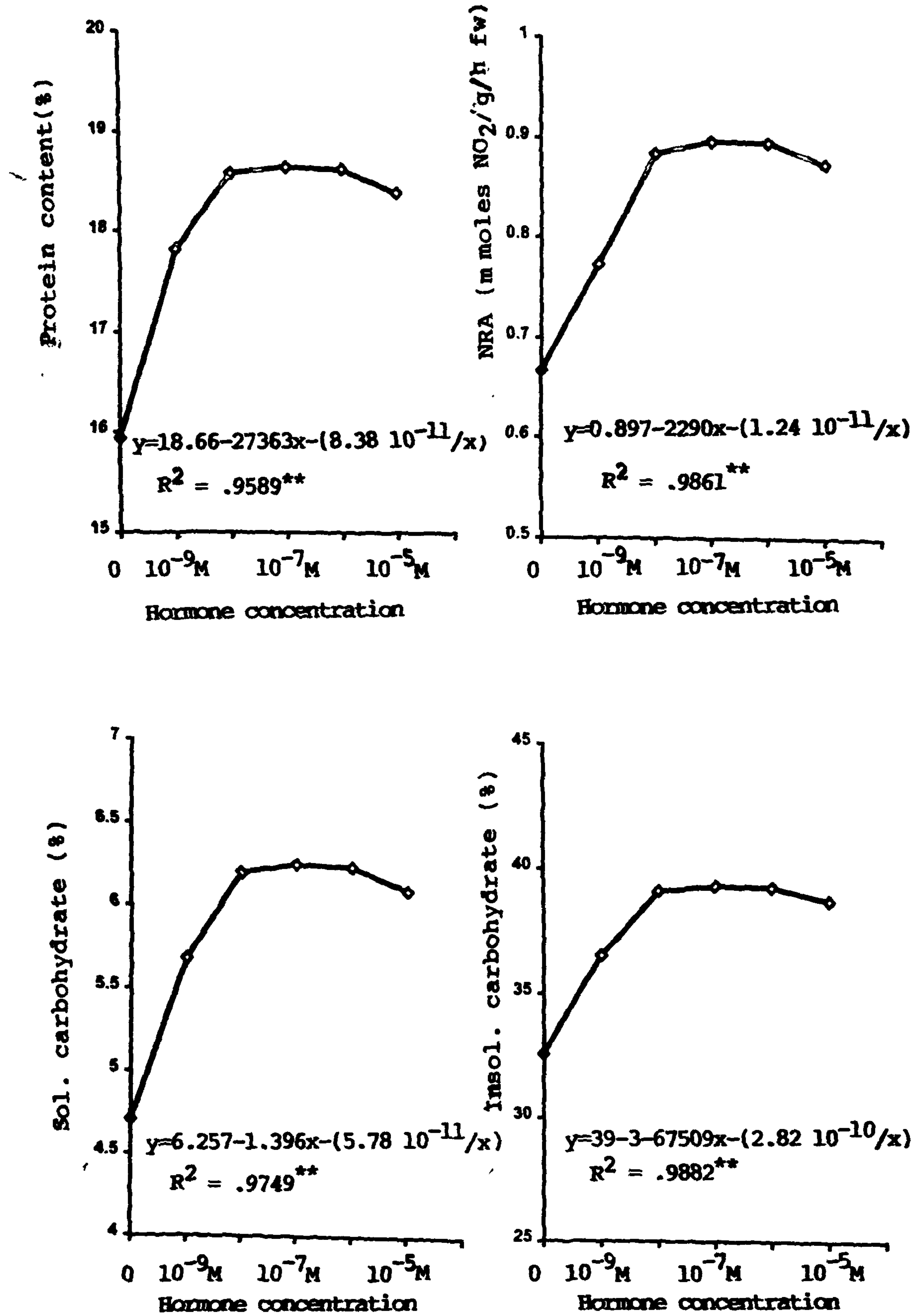

Fig. 4. Regression results showing the relation between the concentration of the hormone and the protein, NRA, soluble and insoluble carbohydrate in root of pea.

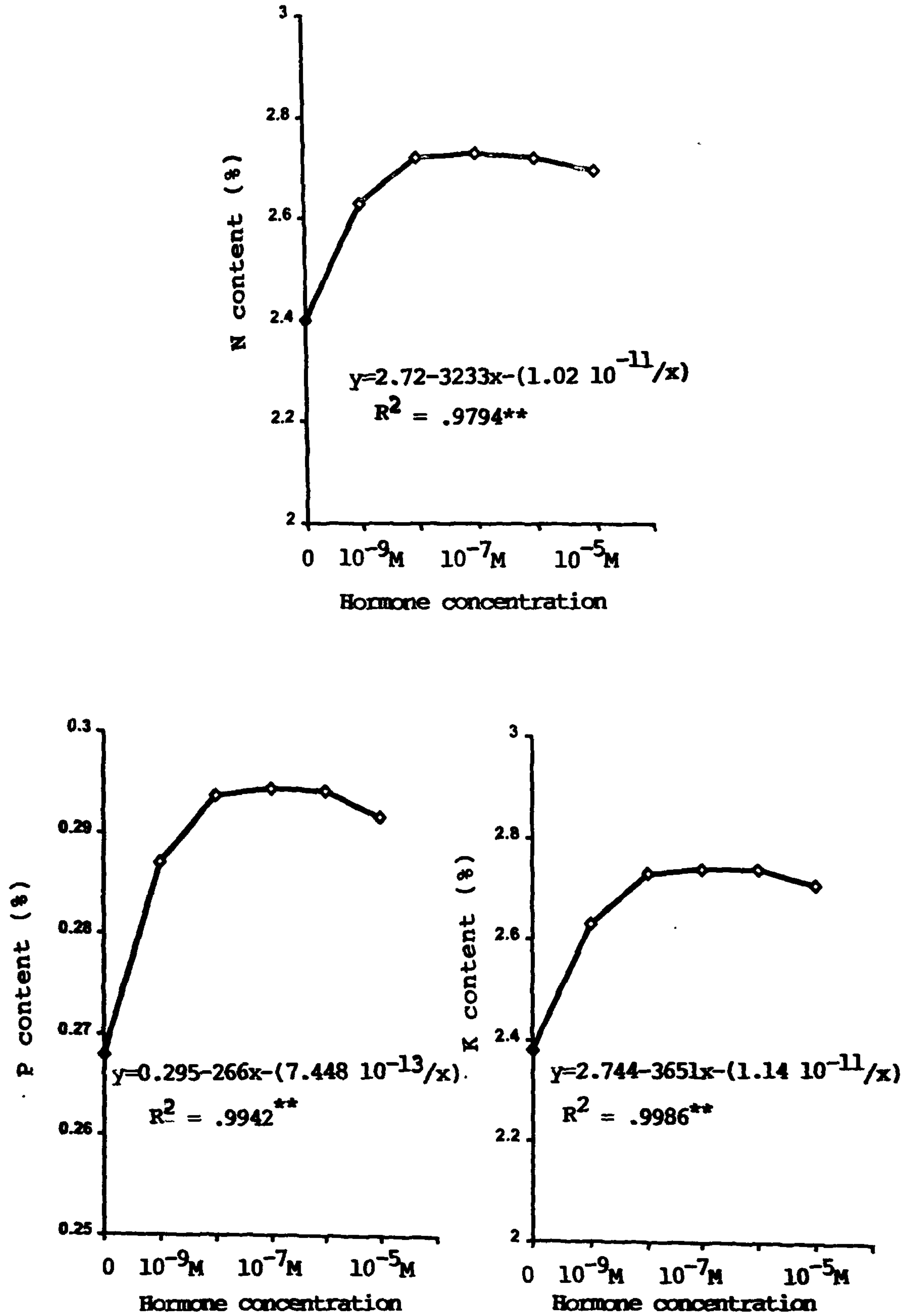

Fig. 5. Regression results showing the relation between the concentration of the hormone and the contents of nitrogen, phosphorus and potassium in shoot of pea.

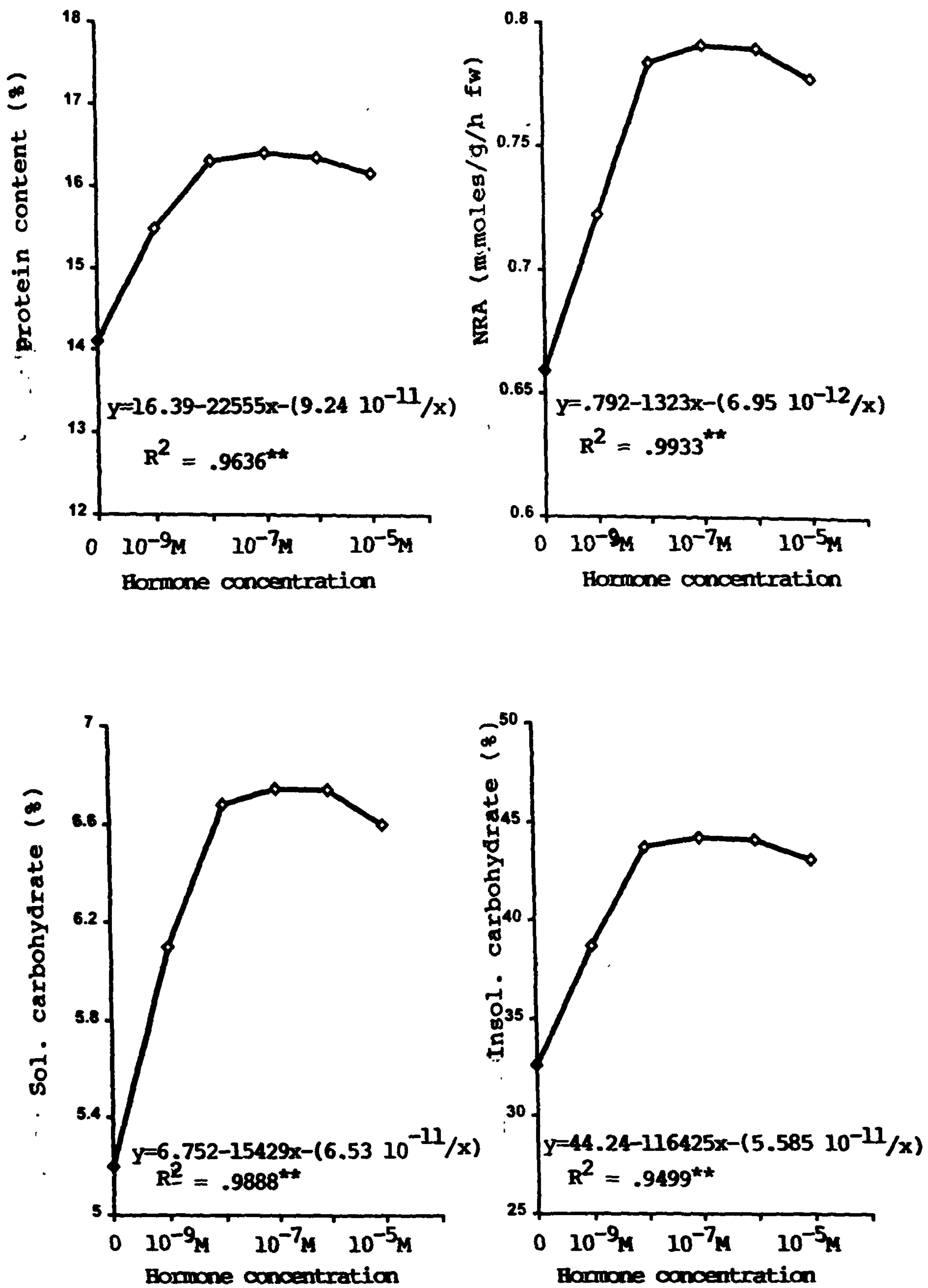

Fig. 6. Regression results showing the relation between the concentration of hormone and the protein, NRA, soluble and insoluble carbohydrates in shoot of pea.

CONCLUSIONS

The following conclusions may be drawn from the present study.

(i) The contents of the carbohydrate, protein and the nutrients in the embryonic axes improved, as the germination advanced, on the expense of that of the cotyledons.

(ii) The activity of nitrate reductase (NR) both in the cotyledons and the embryonic axes increased with time. However, the former had a level much higher than that of the latter. Cotyledons possessed larger quantities of the nitrate than the embryonic axes. The hormonal treatment had an additive effect on NR both in the seed and the seedling.

(iii) The physiomorphological characteristics both of the root and shoot of the plants, received hormonal treatment, were improved. The former was more responsive to auxins and the latter to gibberellin.

(iv) The carbohydrate, protein and nutrient (NPK) content in the seedlings raised either from the treated seeds and/or supplied with the hormones, in the nutrient solution, was more than that of the control.

(v) The seedlings either raised from the seeds pre-treated with 10^{-5} M of the hormone for 12 hours and/or supplied repeatedly (7th and 14th day, of the emergence of the seedling) with 10^{-8} to 10^{-6} M of the hormone, in association with the nutrient solution, exhibited healthy growth.

Chapter 6

SUMMARY

SUMMARY

This thesis is based on the following five chapters.

Chapter 1, includes the significance of the problem entitled, "Response of *Pisum sativum* L. to exogenously applied plant growth regulators".

Chapter 2, represents a comprehensive review of the available literature pertaining to germination, vegetative and reproductive growth and metabolic changes in seeds and/or the seedlings.

Chapter 3, explains the details of the materials and methods employed in conducting the experiments and chemically analyzing the biological material.

Chapter 4, comprises of the tabulated data and its brief description, recorded during this study.

Chapter 5, deals with the defence of the observations, in the light of the already reported related matter.

The salient features of the observations, recorded in each of the four experiments, are summarized below:

Experiment 1

The seeds of pea cv. Arkil were soaked in water (C_1), 10^{-9} (C_2), 10^{-7} (C_3) or 10^{-5} (C_4) M aqueous solution of GA_3 (H_1), IAA (H_2) or IBA (H_3) for 6 (S_1), 12 (S_2) or 18 (S_3) hours in sterilized petriplates at 25±2°C.

The level of NPK, nitrate, NRA, total protein and soluble and insoluble carbohydrates improved in the embryonic axes with the progress of germination but decreased in the cotyledons. However, the treatment remained ineffective in inducing any impact on any of these parameters of the seeds upto 18 hours of soaking.

Experiment 2

The seeds treated with hormones (Experiment 1) were sown in the pots filled with acid washed sand. The resulting seedlings were sampled 25, 35 and 45 days, after sowing and assessed for their length, fresh and dry weight of the shoot and root, separately. They were further subjected to chemical analysis for NRA, nitrate, NPK, protein and carbohydrate contents both in the root and the shoot, separately. The auxins and the gibberellin significantly improved all the growth characteristics of the root and the shoot, respectively. The level of the nitrate in the root only and that of NRA and soluble carbohydrate both in root and shoot was enhanced by GA_3, whereas the nitrate content in the shoot increased by IAA. The treatment was most effective if the seeds were soaked for longer durations (12 or 18 hours) in the higher concentrations (10^{-7} or 10^{-5} M) of the hormones.

Experiment 3

The surface sterilized pea seeds were sown in acid washed sand, in the pots. The seedlings were supplied with 10^{-9}, 10^{-7} or 10^{-5} M of the hormones (IAA, IBA or GA_3) in association with the nutrient solution, once (7th or 14th day) or twice (7th and 14th day), after the emergence of the seedlings. The seedlings were sampled and assessed for various characteristics (Experiment 2). The various root and shoot growth characteristics were significantly enhanced by the treatment. GA_3 was most prominent in improving majority of the components, both that of the root and the shoot. Supply of the hormones twice prevailed, in its effect, over single application.

Experiment 4

This experiment is the combination of Experiment 2 and 3 where the seeds pre-treated with hormones (Experiment 2) were sown in acid washed sand and the seedlings were supplied with additional quantity of the hormones (Experiment 3). The seedlings were sampled and analyzed on the same pattern as in Experiment 2. It was noted that auxins proved best in improving the growth characteristics of the root whereas the shoot gave maximum response to GA_3. Like Experiment 2, repeated application of the higher concentrations (10^{-5} or 10^{-7} M) of the hormones proved superior than single application. In root, the auxins improved NRA, nitrate and soluble carbohydrates whereas NPK and proteins exhibited a significant response to GA_3. Moreover, auxins proved best for the shoot nitrate content but NPK, proteins and soluble and insoluble carbohydrates were largely influenced by GA_3. Most of the factors interacted significantly, mostly at the early stage of growth (25 DAS) only.

The thesis is apended with an up-to-date bibliography of the references cited in the text.

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APPENDIX

APPENDIX

PREPARATION OF REAGENTS

The various chemicals/reagents used for biochemical analysis were prepared by adopting the following procedures.

1. Reagents for the estimation of nitrate reductase activity (NRA)

1.1 Phosphate buffer (pH 7.5)

(a) 13.6 g potassium dihydrogen orthophosphate (KH_2PO_4) was dissolved in sufficient quantities of double distilled water (DDW) and the final volume was made upto 1000 cm^3.

(b) 17.4 g dipotassium monohydrogen orthophosphate (K_2HPO_4) was dissolved in adequate amount of double distilled water and the final volume was made upto 1000 cm^3.

(c) 160 cm^3 of solution (a) and 840 cm^3 of solution (b) was mixed in order to get the required pH 7.5.

1.2 Potassium nitrate (0.2 M)

2.0 g potassium nitrate was dissolved in required quantity of DDW and the final volume was made upto 100 cm^3.

1.3 Isopropanol solution (5%)

5 cm^3 isopropanol was added to 95 cm^3 of DDW.

1.4 NED-HCl solution (0.02%)

20 mg N-1-(naphthyl)-ethylene diamine dihydrochloric acid (NED-HCl) was dissolved in enough DDW and the volume was made upto 100 cm^3.

1.5 Sulphanilamide solution (1%)

1g sulphanilamide powder was dissolved in 100 cm^3 of 3N hydrochloric acid.

1.5.1 Hydrochloric acid (3N)

26.2 cm^3 pure hydrochloric acid was added to enough DDW and the final volume was made upto 100 cm^3.

2.0 Reagents for the estimation of nitrate

2.1 Phenoldisulphonic acid reagent

25 g pure white phenol (AR) was dissolved in 150 cm^3 of pure concentrated sulphuric acid to which 75 cm^3 fuming sulphuric acid was added (13% SO_3). The solution was heated for about 2 hours at 100°C in waterbath. This solution was kept in the dark bottle in a refrigerator.

3.0 Reagents for the estimation of proteins

3.1 Reagent A

2% sodium carbonate was mixed with 0.1N sodium hydroxide (1:1).

3.2 Reagent B

0.5% copper sulphate was added to 1% sodium tartrate (1:1).

3.3 Reagent C (alkaline copper sulphate solution)

It was prepared by mixing 50 cm^3 reagent 'A' with 1 cm^3 reagent 'B'.

3.4 Reagent D (Carbonate copper sulphate solution)

It was prepared in the same way as reagent 'C' except the omission of sodium hydroxide from reagent 'A'.

4.0 Reagents for the estimation of carbohydrates

4.1 Sulphuric acid (1.5 N)

10.2 cm^3 pure sulphuric acid (AR) was added to required quantity of DDW and the final volume was made upto 250 cm^3.

4.2 Phenol (5%)

5 cm^3 distilled phenol was mixed with 95 cm^3 DDW.

5.0 Reagents for the determination of N and P

5.1 Molybdic acid reagent (2.5%)

6.25 g ammonium molybdate was dissolved in 75 cm^3 10 N H_2SO_4. 175 cm^3 DDW was added, in this solution in order to get 250 cm^3 of the above reagent.

5.2.1 Sulphuric acid (10 N)

27.2 cm^3 sulphuric acid was added carefully to DDW and the final volume was made upto 100 cm^3.

5.3 Amino-naphthol sulphonic acid

0.5 g 1-amino-2-naphthol-4-sulphonic acid was dissolved in 195 cm^3 of 15% sodium bisulphite solution to which 5 cm^3 of 20% sodium sulphite solution was added. The above solution was stored in a dark coloured bottle in refrigerator.